FINAL REPORT

19980016

SASKATCHEWAN SPECIALTY LIVESTOCK "VALUE ADDED PROGRAM"

March 2003
Funded by the Agri-Food Innovation Fund

Prepared by: University of Saskatchewan

AGRI-FOOD INNOVATION FUND

Canada

Saskatchewan

103-04311/

SASKATCHEWAN SPECIALTY LIVESTOCK VALUE-ADDED PROGRAM

Saskatchewan Agri-Food Innovation Fund (AFIF)
Project # 98000016

Final Report

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March, 2003

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Summary and Acknowledgements

Summary:

Specialty livestock meat industry faces many chalienges, most importantly inherent palatability issues and proper marketing of meat and meat products. Due to a lack of an organized industry structure, producers are facing an uphill battle to make specialty livestock farming a profitable venture. One of the limiting factors in acceptance of specialty products is that they tend to be very lean and are often over cooked. Resultant products are dry and give the consumer an unpleasant eating experience. This can be easily overcome through the inclusion of marinades or non-meat ingredients at levels sufficient to compensate for most of the cooking losses, resulting in a more succulent and satisfying eating experience without losing the characteristic flavour of the meat in question. Main emphasis of this project has been to improve the tenderness of lesser value cuts and thereby increasing the overall value of the carcass. The findings from various studies conducted under this project suggest that marination by injection has a great deal of potential in improving the palatability of lesser value cuts of meat. In this study only salt and phosphate were used for marination; the opportunities can be further widened by using a combination of different herbs, spices and flavours. Processors can successfully use this technology to produce value-added meat products from specialty livestock.

The preservation of appearance and quality is essential during the distribution and merchandising of perishable products like meat. The only criterion consumers have at the point of purchase when selecting meat cuts is visual appearance. During retail display, to prevent product shrinkage and delay the onset of product deterioration, optimum storage temperature and appropriate packaging is necessary. Currently, vacuum packaging (VP) and modified atmosphere packaging (MAP) with one or more gases are being used by the industry to design different conditions to maximise the shelf-life of meat and to promote desired product characteristics. Most commonly employed gases for MAP are carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2). The data acquired from this project suggested that modified atmosphere packaging (70% O_2 and 30% CO_2) is an excellent option for short-term storage of bison meat due to its positive effects on meat colour but for longer storage, vacuum packaging still holds well. Storing meat under VP and then placing it under MAP just before retail display might be another option to increase product shelf-life.

Volatiles were collected from the meat of emerging species including bison, elk, deer, emu, wild boar, lamb and goat as well as those from domestic species including beef and pork. Aliphatic aldehydes and alcohols, some unsaturated analogs and only a very small amount of heterocyclic compounds dominated the aromagrams so obtained. This was not surprising because lipid degradation products are known to contribute to meat flavour and have low odour threshold values (in the parts-per-billion range). From a qualitative standpoint there was a striking resemblance between the aroma profiles of meats from specialty livestock, but quantitatively there were differences. In this study, the dominant volatiles found in species such as elk, deer, emu, lamb and goat were 1-pentanol, hexanal, 2-furaldehyde, 1-octen-3-ol and 1-octanal. In pork and wild boar these volatiles were present in addition to marked amount of 4-methyl-1-penten-3-ol, nonanal, *E*-2-nonenal, and *E,E*-2,4-decadienal. In cooked bison meat over 200 volatile constituents were separated of which 114 were identified based on retention time matching of authentic standards, Kováts indices and mass spectral data. Of the compounds identified, there were 34 aldehydes, 23 alcohols, 21 ketones, 21 hydrocarbons & aromatics and 15 heterocyclic, halogenated and miscellaneous compounds.

Apart from its main objective of designing processes to improve palatability of specialty meats, the program has tried to address some of the basic questions regarding domestic and foreign trade of specialty meats. The information collected on this subject has been collated into a coherent package. This easy-to-use, quick reference guide is not only relevant to specialty meats (*i.e.*, from bison, deer, elk, wild boar, goat, ostrich, emu and other ratites), but also offers regulation information pertaining to meats from domestic species (*e.g.*, beef, pork, mutton).

Acknowledgements:

Financial support for this program by the Saskatchewan Agri-Food Innovation Fund is gratefully acknowledged. We would like to thank the Dean, College of Agriculture, and the Head, Department of Applied Microbiology and Food Science, for providing us the infrastructural and administrative support for this program. Thanks are expressed to the personnel from the Saskatchewan Food Product Innovation Program for their technical assistance: D.D. Pobereznek, W.P. Rogers, and R.T. Sefton for meat processing and product development, H.D. Silcox for chemical analysis and M. Dworaczek for

microbiological analysis. We would also like to thank D.J. Prefontaine and S.Y.C. Lui from the Saskatchewan Food Industry Development Centre for their continued support during various activities of the program. The authors acknowledge the support of K. Erin (Food Processing Development Centre, Leduc, AB) and J. Aalhus and J. Janz (Agriculture and Agri-Food Canada Research Centre, Lacombe, AB). Contributions of J. Hobbs and A. Cooney from the Specialized Livestock Marketing Research Group (Department of Agricultural Economics) are also acknowledged. Thanks are also due to various personnel from the Saskatchewan Agriculture, Food and Rural Revitalization for their input in the program.

Specialty Livestock Value-Added Program (SLVAP)

Introduction

The thrust of this project was to develop a vehicle that focuses on the development and expansion of value-added processing of emerging species in Saskatchewan. This program cooperated with existing programs for R&D in the meat industry currently being undertaken at the University of Saskatchewan. Drawing from the expertise of the ADF-funded Saskatchewan Food Product Innovation Program (SFPIP) and through use of the existing facilities, the main objective of the SLVAP was to conduct research and development of emerging species' products. In other words, the project's focus lied on the expansion of the specialty livestock meat industry by initiating an increase in the level of activity in this sector. The program provided assistance to manufacturers of specialty livestock products for the development of higher value-added products and processes. To this end, the program was also involved in exploring technologies that would allow meats to be processed into value-added products. Furthermore, we aimed to offer technical expertise to help address issues that might arise in the development of specialty livestock products for export markets. The research undertaken by the program addressed several key concerns that were identified as areas requiring development in the Saskatchewan Specialty Livestock Marketing Study prepared by PPD Technologies Inc. in 1998.

The program was designed with the following objectives in mind:

1. To improve the palatability and to value-add lesser cuts of meat from specialty livestock by existing and possibly novel processing technologies (*e.g.*, marination).

2. To determine the shelf-life of retail cuts and to address demand for fresh meat delivery into foreign markets so as to prolong meat quality during extended storage via packaging technologies (*e.g.*, VP, MAP).

3. To investigate the flavour of meat from specialty livestock as a means to better understand its makeup so that possible strategies can be developed in order to control/limit the impact of undesirable flavour-active compounds in processed meat products.

4. To compile a summary of current regulations required for emerging species (*i.e.*, value-added meat products) to adhere to export standards for shipment to North America, the European Union (EU) and some selected Asian markets.

5. To provide industry support to assist in the development of a sustainable specialty livestock processing industry and in turn increase viable overall growth of this industry in Saskatchewan.

All the objectives mentioned above have been addressed in detail in the following sections.

Executive Summary

The specialty livestock meat industry has grown slowly, but steadily. There is a general perception that meat from specialty livestock is less tender, darker in colour and has a strong game flavour compared to that from domestic species. These sensory perceptions about game meat are some of the problems that exist in marketing meat and meat products from specialty livestock species. Over the past three years, personnel involved with the Saskatchewan Specialty Livestock Value-Added Program (SLVAP) have been busy in addressing some of these issues. Sincere efforts were made to publicize the program and to reach as many producer/processor groups, industry and government personnel as possible.

Research activities included the following: improving the palatability of bison top round steaks and roasts with the help of marination supplemented by a consumer study (note: this was done in collaboration with Agriculture and Agri-Food Canada Research Centre, Lacombe, AB); evaluating the effects of marinade composition and cooking method on the tenderness of elk roasts; monitoring the effects of cooking cycle on the tenderness of bison and beef roasts; finding the effects of vacuum and modified atmosphere packaging on the colour and shelf-life of bison and beef steaks; and investigating the flavour of meat from specialty livestock as a means to better understand its makeup so that possible strategies might be developed in order to control or limit the impact of undesirable flavour active compounds in processed meat and meat products.

Due to the small size of the specialty livestock meat industry, the required number of samples was one of the major hurdles we faced when conducting these studies. Consequently, bison and elk (as a representative of all cervids) were the two main specialty livestock species from which meat was used for palatability and other experiments. Note however, a good number of product development projects were undertaken for other species *e.g.*, whitetail and mule deer, goat, wild boar, emu and ostrich. We believe that the bison meat industry has come a long way over the past few years, and we consider it to be the major specialty livestock industry in the province. The Saskatchewan Bison Association has shown continued interest in SLVAP and has helped in sourcing meat samples at various times. Findings from these studies were and are being passed on to producers and

processors involved with specialty livestock through fact sheets/newsletters, and have also been presented at scientific meetings as well as being published in industry magazines and international peer-reviewed journals (*e.g.*, Meat Science, Journal of Food Science, Small Ruminant Research and Asian-Australasian Journal of Animal Science). With the support of the Saskatchewan Food Product Innovation Program (SFPIP), the SLVAP updated its mailing/contact list (~1200 producers, meat processors and personnel from government departments), initiated a web site, developed a new-look brochure and distributed its yearly newsletters. One of the main achievements over the past year has been the publication of a guide for "Export and Labelling Regulations for Specialty Livestock Meat and Meat Products." This easy-to-use guide is not only relevant to specialty meats, but also offers regulation information pertaining to meat from domestic species and should be a handy reference guide for individuals or organizations involved in meat trade. The program also participated in many workshops, field days, meetings and conferences related to specialty livestock so as to gather knowledge and make contacts with the people involved in this sector.

With regard to assisting the specialty livestock meat industry in developing value added meat and meat products: the program, in conjunction with the SFPIP, was involved with various producer/processor groups. Many technical assistance projects in the form of consulting and/or troubleshooting, extension were undertaken, in addition to the product development initiatives. The SLVAP complemented and utilized the expertise of the SFPIP. Initially, Mr. Derrick Pobereznek, product development specialist with the SFPIP, assisted the program but he left in January 2001 and accepted a position with Mitchell's Gourmet Foods. In his place Mr. Paul Rogers, who has over 15 years of experience in product development with Maple Leaf Foods and Schneider's Meats, was hired and he has been with the SFPIP since April 2001. During the past three years, there has been an increase in the growth of the specialty livestock sector, especially the bison industry. The program hired a part-time chef to work with the program's meat scientist and SFPIP's product development specialist. Through this activity, we were able to develop some enticing value-added meat products from bison. Of particular interest was to value add some of the less tender cuts of bison such as top round. Thus, emphasis was placed on increased tenderness and flavour of lean bison meats. We showcased one of the products (bison kebobs) at the Annual Field Day of the Saskatchewan Bison Association (July 20-22, 2001) and it was very well received by the attendees.

One of the major product development projects undertaken by the program was in collaboration with the Saskatchewan Bison Association, Specialized Livestock Marketing Research Group (Department of Agricultural Economics) and Saskatchewan Food Industry Development Centre, in an AFIF-funded project. This project analyzed the consumer demand for bison meat products in key Canadian markets and focused on the lesser value bison cuts. The project's aim was to better understand consumer preferences for bison, the preferred characteristics of bison meat products and the "willingness-to-pay" for these products by consumers. As already mentioned, the main focus of SLVAP was to conduct research and to help in the development of the specialty livestock meat industry. For this reason, efforts were directed mostly towards research and outreach activities. As consumer awareness and demand for leaner meat products increase and specialty livestock herd sizes become larger, we expect to see a greater demand for product development assistance to the industry in the future.

During the past three years, the SLVAP was in attendance at many trade shows, meetings and conferences to make contacts with potential clients in the specialty livestock sector. These included the Saskatchewan Bison Association Annual Field Day, Annual Conventions of Saskatchewan Whitetail and Mule Deer Producers Association, Saskatchewan Elk Breeders' Association and Saskatchewan Meat Processors' Association. To publicize the program and its research activities, a number of news articles were published in various magazines and newspapers *e.g.*, Times Food Processing Journal – a food industry magazine published from India, the FORUM – the official publication of the Saskatchewan Meat Processors' Association, the official Newsletter of the American Meat Science Association, the TRACKING magazine – a publication of the Saskatchewan Whitetail and Mule Deer Producers Association, the TRACKER magazine focusing on the Bison, Deer and Elk Industries and the Western Producer. The program also developed a fact sheet on marination by injection and its role in improving the palatability of bison meat, which has been posted on the SFPIP website (www.ag.usask.ca/sfpip). This document has also been posted by the Bison Centre of Excellence, Leduc, AB on its website (www.bisoncentre.com). Liaisons have been made with personnel from other programs related to specialty livestock such as the Specialized Livestock Marketing Research Group (Department of Agricultural Economics), Specialized Livestock Research Program (Western College of Veterinary Medicine) and Saskatchewan Agriculture Food and Rural Revitalization. These associations have helped the SLVAP in deciding the direction and selection of its future research projects by receiving feedback from the industry and producer organizations.

Good communication links were made with several other specialty livestock associations (*e.g.*, the Saskatchewan Bison Association, Canadian Cervid Council, North American Bison Cooperative, North American Elk Breeders Association, Canadian Boer Goat Association) as well as many other producers and small processors.

Highlights:

- In March 2000, Dr. Jag Dhanda, Meat Scientist, joined the SLVAP.
- In April 2000, the Saskatoon Extension Office of Saskatchewan Agriculture and Food, SLVAP and SFPIP conducted a seminar on Goat Meat Production. A portion of this event (*i.e.*, goat carcass evaluation and preparation of carcass cuts) took place in the meat processing pilot plant at the University of Saskatchewan.
- A research project on improving the palatability of bison meat was completed in December 2000 in collaboration with Agriculture and Agri-Food Canada Research Centre, Lacombe, AB.
- In the year 2000, a new brochure was developed for the program and efforts were made to update the SLVAP mailing/contact list in collaboration with SFPIP. The new brochure along with SLVAP'S first newsletter was distributed to ~1200 individuals, which included producers, processors, industry and government personnel.
- A major product development project was undertaken by the program in 2001-2002 in collaboration with the Saskatchewan Bison Association, Specialized Livestock Marketing Research Group (Department of Agricultural Economics) and Saskatchewan Food Industry Development Centre, in an AFIF-funded project. This project analyzed consumer demand for bison meat products in key Canadian markets.
- In continuation with the bison marination project, a research project on the "effects of different levels of phosphates in the marinade on the palatability of elk meat" was completed in the year 2001.
- In the year 2001, a project on developing some enticing value-added products from bison meat was completed. For this project, the SLVAP hired a part-time chef to work with the program's meat scientist and product development specialist from the SFPIP.

Emphasis was on increased tenderness and flavour of lean and less tender bison meat cuts.

- The program developed a fact sheet on the marination by injection and its role in improving the palatability of bison meat in the year 2001. This information has been posted by the Bison Centre of Excellence on its website (www.bisoncentre.com). The fact sheet along with the SFPIP newsletter was distributed to ~1200 individuals (producers, processors, industry and government personnel).

- A guide to Export and Labelling Regulations for Specialty Livestock Meat and Meat Products authored by J.S. Dhanda, D.J. Schenher, S.Y.C. Lui, R.B. Pegg, P.J. Shand and D.J. Prefontaine was released in January 2003.

- A review article entitled "Goat meat – A potential red meat alternative" authored by J.S. Dhanda, R.B. Pegg and P.J. Shand appeared in the July issue of Times Food Processing Journal.

- A second review article on goat meat entitled "Goat meat production: Present status and future possibilities" authored by J.S. Dhanda, D.G. Taylor, P.J. Murray, R.B. Pegg and P.J. Shand was written in collaboration with scientists from the University of Queensland, Australia and has been submitted for consideration of publication in the Asian-Australasian Journal of Animal Science.

- Research findings from the marination study on elk meat were presented at the 48th International Congress of Meat Science and Technology held in Rome, Italy, from August 25-30, 2002.

- In 2002, a study was conducted to assess the influence of packaging (modified atmosphere and vacuum) and storage conditions on the colour stability of beef and bison steaks. It was observed in this study that bison meat bloomed quickly and had a darker red colour, but it tended to loose its brightness readily on storage compared to beef. This data suggested that packaging in modified atmosphere is an excellent option for short-term storage due to its positive effects on meat colour but for longer storage, packaging under vacuum still holds well. A research publication from this study is in preparation.

- A number of articles about the research activities and services offered by the program were published in various magazines and newsletters to reach as many people as possible. The publication sources include the "Forum" (Saskatchewan Meat Processors Association), the "TRACKING" (Saskatchewan Whitetail and Mule Deer Producers Association), the "TRACKER" (Bison, Deer and Elk Industries), official newsletter of the American Meat Science Association and the Western Producer.

- Personnel from the program attended a number of trade shows/conferences/meetings etc. during the last three years. These included Saskatchewan Elk Breeders' Annual Conventions, Meat Goat Production Seminar, International Bison Conference, Annual Conventions of Saskatchewan Meat Processors' Association, Saskatchewan Whitetail and Mule Deer Producers' Association Annual Conventions, Saskatchewan Bison Association Annual Field Days, Grand Opening of the Saskatchewan Food Industry Development Centre, International Animal Agriculture and Food Science Conference and International Congress of Meat Science and Technology. Important new contacts were made during these meetings.

Activity 1.1: Effects of Marination on the Processing Parameters and Palatability of Bison Top Round Steaks and Roasts

Background and Objectives:

Demand for bison meat is currently increasing faster than the production rate. The main concern is inconsistency in terms of both the quality and quantity of bison meat available in the market. To meet domestic demand and to take bison further into the international market, further processing is the key to ensure a consistent product. Injection of phosphate and salt-containing marinades has been shown to increase the palatability of a wide variety of meat products, but many of these studies have been based on domestic species (*i.e.*, beef and pork) Keeping this in mind, the present trial was conducted to investigate the effects of marinades, containing sodium chloride and sodium tripolyphosphate, on the yield, colour, tenderness and consumer acceptability of bison top round steaks and roasts cooked by two different methods and to two endpoint temperatures.

One of the hurdles in carrying out research on specialty meats is the availability of meat of assured quality. The goal was to attempt to obtain meat from a federally-inspected slaughter facility. This project was carried out in collaboration with the Agriculture and Agri-Food Canada Research Centre, Lacombe, AB, where a project on novel methods of tenderizing bison meat is being conducted. This collaboration enabled us to obtain the meat required for our study.

Materials and Methods:

History of animals and post-mortem treatments before sampling: Ten intact males, aged between 24 and 30 months (feedlot finished on alfalfa/barley mix) were slaughtered at the Agriculture and Agri-Food Canada Research Centre, Lacombe, AB. The carcasses were evaluated as having grades in the range from A1 to D1. One side of the carcass (either left or right; chosen alternately to neutralize side effects, if any) was subjected to very fast

chilling at a temperature of -35°C for 2 or 4 hours followed by conventional chilling at 2°C until ~24 hours post-mortem, while the other side was chilled under conventional conditions (2°C for 24 hours) soon after slaughter and served as a control. After chilling, the top rounds (inside rounds) were separated, vacuum packaged and aged until 6 days post-mortem at 4°C and then stored frozen at -30°C before shipping to the Department of Applied Microbiology and Food Science, University of Saskatchewan, where the present study was carried out.

Sampling and processing procedures: After thawing (at 4°C for 72 hours), 20 paired bison top rounds were trimmed of any visible fat. The *adductor* muscles were separated from the top rounds and the *semimembranosus* (SM) muscles were used for this study. Each of these 20 SM muscles was divided longitudinally in half. One of these sections was injected with brine containing sodium chloride and sodium tripolyphosphate to achieve 10% extension by weight, while the other side was kept as a non-injected control. The treatments were rotated so that both are represented equally in both muscle sections of all 20 SM muscles. The sections designated for marination were injected to a target weight gain using a multi-needle injector. Re-injection with a hand held injector compensated for any difference in the target weight. Injected sections were allowed to equilibrate for 5 minutes following injection to allow drainage. The brine solution used for injection was formulated to achieve 0.5% (w/w) sodium chloride and 0.3% (w/w) sodium tripolyphosphate in the finished marinated product. After injection, the muscle samples (control and injected) were vacuum packaged and stored at -1°C for 24 hours.

Muscle samples were then sliced, starting from the centre and going towards both sides, so as to obtain four uniform 3.81 cm thick steaks, two other 1.27 cm thick steaks and two roasts. Of the four 3.81 cm thick steaks, two were used for evaluation of the tenderness after dry-heat cooking while the remaining two were labelled, vacuum packaged and stored at -30°C and used later for sensory evaluation by a consumer panel. The end roasts were also evaluated for tenderness after moist-heat cooking to compare these two methods of cooking. The 1.27 cm thick steaks were used for colour appraisal. The position of steaks and roasts was rotated to represent both cooking temperatures (*i.e.*, 71°C and 77°C) in control as well as injected sections of all the muscle samples. As always, corresponding positioned steaks/roasts were used for the comparison between treatments. The marinated product yields, based on the green weight, were calculated after injection.

pH analysis and proximate chemical composition: pH was determined by using 20 g of prepared sample in duplicate. Each sample was blended for 1 minute with 80 ml of distilled water using an Osterizer Model 548 Blender (Sunbeam Corp, Toronto, ON). pH was read on a Fisher Accumet 915, pH Meter (Fischer Scientific, Nepean, ON). The proximate chemical composition of the muscle samples (moisture, protein, fat and ash) from both treatments was determined (AOAC, 1990).

Colour appraisal: The 1.27 cm steaks selected for colour appraisal were packaged on a styrofoam tray with an oxygen permeable film. Efforts were made to simulate retail display conditions. The temperature of the retail case was 3±1°C and the fluorescent lamps used during storage were F40SPEC30 (PHILLIPS). The light intensity was monitored throughout the trial period with the help of a Lutron LX-101 Digital Lux Meter. Light intensity was measured to be 975 lx (950-1000 lx) on average and was on continuously, 24 hours/day. The changes in colour were determined using a HunterLab MiniScan XE (HunterLab machine was set at L*a*b*, observer 10, illuminant A). The colour was read daily at the same position (marked on the steak) and two readings at right angle to one other were recorded for each steak. Furthermore, the change in colour was observed visually.

Cooking of steaks and evaluation of tenderness:

Dry-heat cooking: Two steaks separated for tenderness evaluation were broiled in an oven at 260°C. One steak was cooked to a final internal temperature of 71°C, while the second was cooked to a 77°C end point. The steaks were turned when they reached an internal temperature of 25, 40 and 55°C.

Moist-heat cooking: The two end roasts, remaining from the meat used for tenderness, sensory and colour evaluations, were vacuum packaged in cook and ship bags (inserted with a thermocouple) and cooked in a water bath to the same internal temperatures as used for broiling, that is, 71°C and 77°C, respectively.

The temperatures of the oven/water bath and steaks/roasts were monitored using thermocouples attached to a scanner and a computer, which recorded the change in temperature every 30 seconds. The cook yield of steaks/roasts was also recorded.

After cooling down to an internal temperature of 50°C, cooked steaks/roasts were stored at 4°C for 2 hours. Six to eight cores (1.27 x 1.27 x 3.81 cm) were removed from each

steak/roast parallel to the direction of the muscle fibres. These cores were allowed to equilibrate at room temperature for an hour before tenderness measurements (*i.e.,* shear force values) were carried out; a Food Technology Corporation, TMS-TP Texture Press (Rockville, MD, USA) TMS-90 Computer, and a Model Warner-Bratzler Shear Test Cell with a FTA 300 Transducer were used for this purpose. At the time of cutting cores for shear force analysis, samples from the centre of the steaks and roasts were removed for evaluation of expressible moisture (EM).

Expressible moisture (EM): EM was measured on the same day that the steaks/roasts were cooked. It was determined by a modified method of Jauregui *et al.* (1981) as reported by Foegeding and Ramsey (1986). Briefly, three 1.5 cm cores were taken from an 8 mm slice of a cooked bison steak/roast. Three of these pieces were weighed and placed in 50 ml centrifuge tubes fitted with thimbles consisting of 2 pieces of Whatman # 3 (9.0 cm) folded around 1 piece of Whatman # 50 (5.5 cm) filter paper. Samples in the tubes were stored at 4°C until centrifuged. Centrifugation was done for 10 minutes at 1811 rpm (750x*g*) using a Beckman J2-HC with a JS 4.3 Rotor (Beckman Instruments Inc., Fullerton, CA, USA). Meat samples were weighed again after spinning. The percentage of water lost was reported as EM.

Organoleptic evaluation: As described earlier, the steaks corresponding to those used for shear force analysis were employed for sensory analysis. The steaks were cooked to the same endpoint temperatures (71°C and 77°C) as used for shear force determination.

The sensory analysis was performed using a consumer panel consisting of 80 respondents at the Consumer Product Testing Centre, Edmonton, AB in collaboration with the Food Processing Development Centre, Leduc, AB. The sensory attributes assessed included tenderness, flavour, juiciness and overall acceptability, as well as some demographics. In addition, the program also helped a graduate student of Dr. Jill Hobbs, Associate Professor, Department of Agricultural Economics at the University of Saskatchewan in collecting data on consumer preferences for red meat/bison during the consumer studies. The Specialty Livestock Marketing Research Group headed by Dr. Hobbs used this information as pilot studies for research on bison consumer preferences.

Statistical Analysis: The effects of injection treatment (2; injected and non-injected), cooking method (2; dry- and moist-heat) and cooking temperature (2; 71°C and 77°C) on processing parameters of bison SM (from 10 animals) were analyzed by a split-split plot design. For the

sensory response, dependent variables included in the model were as follows: injection treatment (2; injected and non-injected), cooking temperature (2; 71°C and 77°C) and respondents (80). All data were analysed using the General Linear Model (GLM) procedures of the SAS statistical package (SAS, 1990).

Results:

The data suggest that an injection level of 10% (w/w) could be achieved in bison meat. The average yield achieved for injected sections in this trial was 109%. Due to injection of phosphates, the pH of the injected muscle sections was significantly higher (5.67) compared to control ones (5.40).

Colour Appraisal

In the simulated retail display case, the bison steaks held a bright red colour for 2 days, but on the third day they started to turn brown and by the fourth day onwards, a greenish discoloration was evident. There was no visible difference in the colour between steaks obtained from control and marinated muscle sections, although steaks from the non-injected control sections had a higher purge compared to those from injected sections. HunterLab values (L*a*b* values) showed a slightly different trend than that observed visually. Injected steaks had lower L* (lightness) and b* (yellowness) values compared to non-injected steaks, while a* values did not change significantly between treatments. From day 0 to day 2, the decline in colour values was significant but after that change was quite minimal (Fig. 1.1.1). In total, the change in colour was monitored for 5 days but on day 5, all steaks were grossly discolored. The colour stability of these steaks was very low because we could not access fresh meat, and frozen storage deteriorates meat quality to a significant extent, as it relates to colour. In future, additional work on the colour stability of fresh bison meat might be carried out to elaborate the reasons behind this aspect.

Proximate Composition

The average proximate composition of injected samples for moisture, crude protein, fat, ash and carbohydrate was as follows: 75.8%, 20.5%, 0.57%, 2.08% and 1.28%, respectively, whereas control non-injected samples had 74.4% moisture, 22.0% crude protein, 0.77% fat, 2.09% ash and 0.72% carbohydrate. Significantly higher moisture content (because of marination by injection) of injected samples decreased the percent protein and fat contents

when these values were compared to control ones. The findings also substantiated the fact that bison meat is very lean.

Tenderness evaluation

The percent cooking yield for the steaks and roasts obtained from injected (*i.e.*, marinated) muscle sections was significantly higher (69.8%) compared to those from control non-injected sections (65.4%) when cooked to an internal temperature of either 71°C or 77°C. The injected steaks or roasts also took less time to reach desired endpoint temperatures compared to control steaks and roasts, although differences were not statistically significant. The percent cooking yield was significantly influenced by the method of cooking (*i.e.*, dry- or moist-heat) and the endpoint temperature (*i.e.*, 71°C or 77°C). Cooking by moist-heat and to an internal temperature of 71°C had significantly lower percent cooking losses compared to cooking by dry-heat and to an endpoint temperature of 77°C. A similar trend was observed when evaluating for tenderness (shear force values). Injected steaks and roasts had significantly lower shear force values (63.9±13.8 N) compared to control ones (102.3±21.0 N) (Fig. 1.1.2). Furthermore, the variability in tenderness observed in control samples was reduced to almost 50% by marination. Moist-heat cooking proved to be better than that of dry-heat cooking when shear force values were compared, irrespective of the endpoint temperature (Fig. 1.1.3). As bison meat is very lean, cooking steaks and roasts to a lower temperature (71°C) is more suitable compared to an internal temperature of 77°C (Fig. 1.1.4). When steaks and roasts had been cooked to 77°C, they appeared very dry compared to those cooked to 71°C. This observation was well supported by the values obtained for EM. The data on consumer studies indicated that injected steaks had significantly better acceptance with respect to tenderness, juiciness and flavour compared to control steaks. However the consumers did not significantly differentiate between steaks cooked to internal temperatures of 71°C and 77°C for these sensory attributes.

The findings of the present study suggest that marination by injection has a great deal of potential in improving the palatability of lesser value cuts of bison. In this study only salt and phosphate were used for marination: the opportunities can be further widened by using combination of different herbs, spices and flavours. Processors can successfully use this technology to produce value-added meat products from specialty livestock.

Acknowledgement:

The SLVAP acknowledges the contributions of Dr. Jennifer Aalhus and her graduate student Ms. Jennifer Janz for their assistance in this project.

People Involved:

- **J.S. Dhanda**
- **D.D. Pobereznek**
- **P.J. Shand**
- **R.B. Pegg**
- **H.D. Silcox**
- **C. Yu**

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Note: For further details on this project, please see a research paper published in *Meat Science*, a fact sheet and conference presentations in Appendix 4.

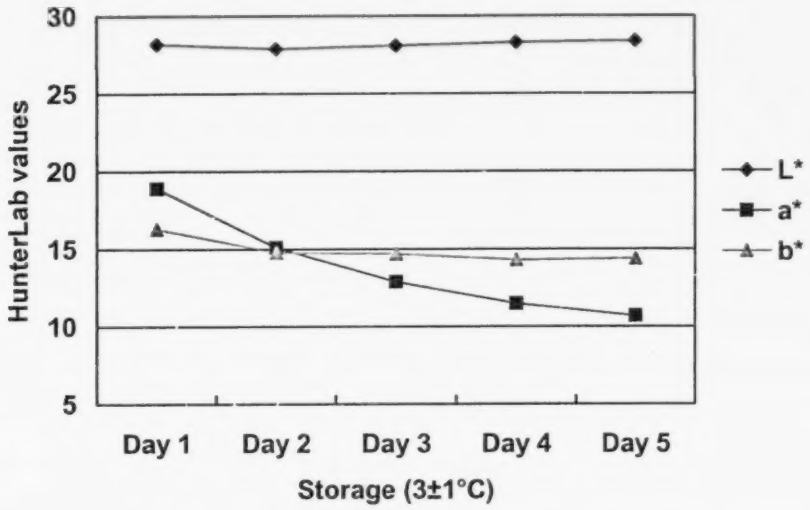

Fig. 1.1.1. Changes in HunterLab colour values (L*, a*, b*) during storage (injected and control data combined).

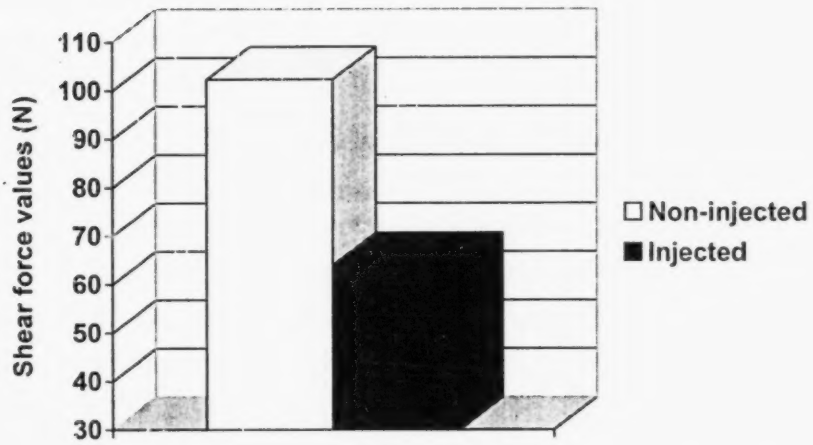

Fig. 1.1.2. Comparison of injected and control steaks/roasts for tenderness (shear force values).

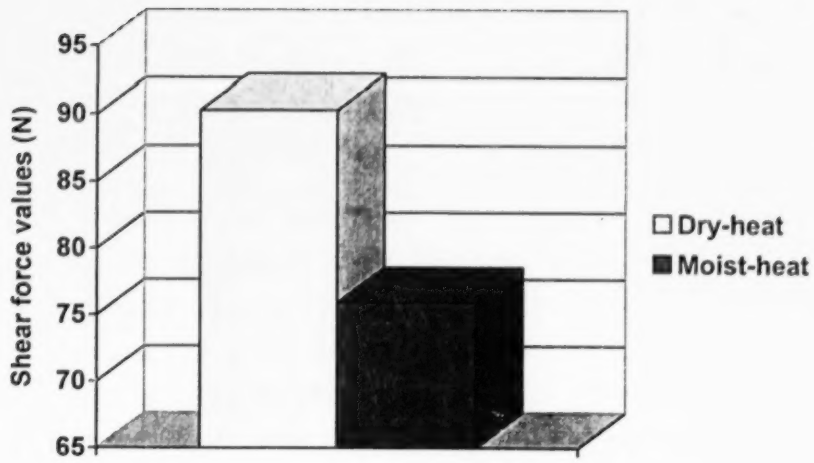

Fig. 1.1.3. Comparison of cooking methods (dry-heat vs. moist-heat) for tenderness (shear force values).

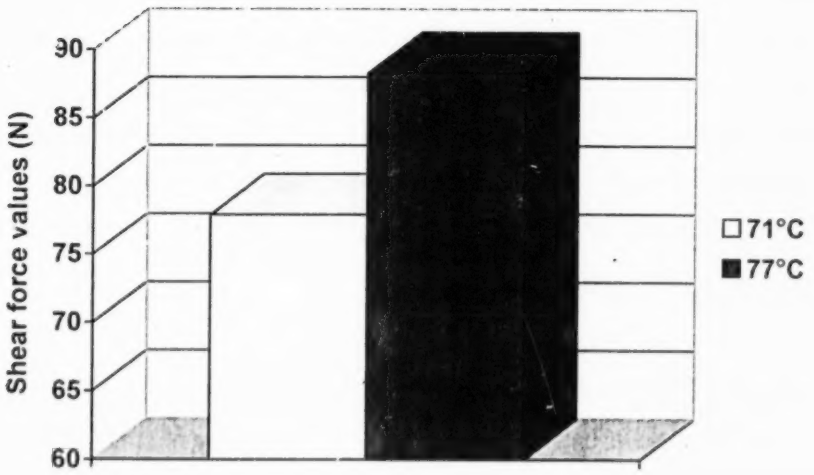

Fig. 1.1.4. Comparison of cooking temperatures (71°C vs. 77°C) for tenderness (shear force values).

Activity 1.2:	Effects of Marinade Compositions and Methods of Cooking on the Tenderness of Elk Top Round and Loin Roasts

Background and Objectives:

In North America, the elk industry thrives mainly on revenues from velvet production and hunt farming. Recently, elk producers' organizations have directed their efforts to utilize culled animals for meat production. The main concern from such animals is inconsistency, both in terms of the quality and quantity of elk meat available in the market. So, further processing may be desirable to improve the sensory characteristics of elk meat to make it an attractive alternative for consumers. Results from Activity 1.1, which involved injection of phosphates and salt containing marinades to improve the palatability of bison top round steaks and roasts were very encouraging. In continuation with these efforts, it was decided to employ this technology on meat from other emerging species, namely elk.

Polyphosphates are commonly used in the production of value-added meat and poultry products. Sodium phosphate has been documented to increase protein solubility and the water-binding capacity, thereby increasing the tenderness and juiciness of the meat. In the study on the marination of bison top rounds, samples were injected with a brine containing sodium chloride and sodium tripolyphosphate to achieve 10% extension by weight with 0.5% sodium chloride and 0.3% sodium tripolyphosphate levels in the finished marinated product. The present study was designed to assess the effects of various concentrations of sodium tripolyphosphate in the marinade on the yield and tenderness of moisture-enhanced elk loin and top round.

Materials and Methods:

History of animals and post-mortem treatments before sampling: Four intact males and four females, aged between 3-5 years and 13-16 years, respectively (carcass weight 163±25 kg) were slaughtered at a local provincially-inspected slaughter facility. After aging for 10 days, the top rounds (inside rounds) and short loins were separated, vacuum packaged and shipped to the Department of Applied Microbiology and Food Science, University of Saskatchewan, for this study.

Sampling and processing procedures: Eight paired venison loin (*longissimus lumborum*, LL) and top round were trimmed off of any visible fat. From the top rounds, the *adductor*

muscles were separated and only *semimembranosus* (SM) muscle was used for this study. The samples were stored frozen at –30°C and one pair of sides was injected at a time, after thawing (at 4°C for 72 hours). LL and SM from each side of the carcass were divided into two equal portions to yield 4 sections, each from the two muscle groups per animal. The following four treatments were rotated so that all treatments were represented in all muscle portions.

Brine solutions were formulated to achieve the following concentrations of salt and phosphate in the finished marinated product:

1. 0% sodium chloride and 0% sodium tripolyphosphate (**Non-injected control**)
2. 0.5% sodium chloride and 0.1% sodium tripolyphosphate (**Injected A**)
3. 0.5% sodium chloride and 0.2% sodium tripolyphosphate (**Injected B**)
4. 0.5% sodium chloride and 0.3% sodium tripolyphosphate (**Injected C**)

The sections designated for marination were injected to a target weight gain of 10% of the original weight using a multi-needle injector. Injected sections were allowed to equilibrate for 5 minutes following injection to allow drainage and were re-injected with a hand-held injector to compensate for any deviation from the target weight. After injection, the muscle samples (control and injected) were vacuum packaged and stored overnight at -1°C. On the next day, two 1.27 cm thick steaks were obtained from either side of the muscle section and used for colour appraisal. The remaining muscle section was carved into two equal-sized roasts; these were employed for tenderness evaluation after cooking. Following injection, the final yield of marinated sections was calculated based on the green weight. The pH, water holding capacity and proximate composition (moisture, protein, fat and ash) of the muscle samples from all treatments were also analyzed.

Muscle samples were then sliced; starting from the centre to obtain two steaks 1.27 cm thick. The remaining muscle section was carved into two-even sized roasts. The 1.27 cm thick steaks were used for colour appraisal. The roasts were used for tenderness evaluation after dry-heat (baked in an oven) and moist-heat cooking (steam cooked in a smoke house); these two methods of cooking were compared. The position of roasts was rotated such that both cooking methods were employed in control as well as injected sections of all the muscle samples. The marinated product yields based on the green weight were calculated

after injection. Samples were also collected from each section for pH, expressible moisture and proximate composition analysis.

Colour appraisal: The 1.27 cm steaks selected for colour appraisal were packaged on a styrofoam tray with an oxygen permeable film. Efforts were taken to simulate retail display conditions. The temperature of the retail case was 3±1°C and the fluorescent lighting employed was F40SPEC30 (Phillips) during the period of storage. The intensity of the lights was monitored throughout the trial period with a Lutron LX-101 Digital Lux Meter. Light intensity was on average 975 lx (950-1000 lx) and remained illuminated 24 hours/day. The change in colour was monitored using a HunterLab MiniScan XE (HunterLab machine was set at L*a*b*, observer 10, illuminant A) colorimeter. The colour was read daily at the same position (marked on the steak) and two readings at right angle to each other were taken on each steak. When taking HunterLab value readings, reflectance measurements at isobestic points (i.e., equal reflectance at a particular wavelength for two or more of the three forms of myoglobin; namely, oxymyoglobin, deoxymyoglobin and metmyoglobin) were recorded and converted to K/S values (Judd and Wyszecki 1963). Ratios of wavelengths were then used in predetermined equations to calculate the different forms of myoglobin, as described by Hunt et al. (1991). The instrument (HunterLab colorimeter) measures the reflectance between 400 and 700 nm at 10 nm intervals. Reflectance values at wavelengths not recorded by the instrument were calculated based on linear interpolation.

Cooking of steaks and evaluation of tenderness: One of the elk roasts was baked in a preheated oven at 165°C, while the second was steam-cooked in a smokehouse to a final internal temperature of 71°C. Before thermal processing, thermocouples were inserted into the geometric centre of roasts. The temperatures of the oven/smokehouse and roasts were monitored by these thermocouples. The probes were attached to a scanner and a computer that recorded the change in temperature every 30 seconds. The cooking time and yield of the roasts were also recorded.

After cooling down to an internal temperature of 50°C, cooked roasts were stored overnight at 4°C. The following day, 6-8 cores (1.27 x 1.27 x 3.81 cm) were removed from each roast parallel to the direction of the muscle fibres. These cores were allowed to equilibrate at room temperature for an hour before measurements (shear force values) were taken. Tenderness measurements were made as described in Activity 1.1.

pH analysis, proximate chemical composition and expressible moisture (EM): pH, chemical composition and EM were determined as described in Activity 1.1.

Fatty acid composition of muscle samples: Total lipids were extracted from raw non-injected muscle samples (15 g) from each animal according to the classical Bligh and Dyer (1959) assay. Fatty acid methyl esters (FAMEs) were prepared from the lipid extract (ca. 10 mg) after addition of an internal standard (250 ng/100 µl chloroform, heptadecanoic acid; C17:0; Sigma-Aldrich Canada Ltd., Oakville, ON, Canada). Transmethylation was done according to Keough and Kariel (1987). The FAMEs were dissolved in 1 ml of carbon disulphide and used for gas chromatographic analysis. An Agilent 6890N gas chromatograph (Agilent Technologies, Wilmington, DE, USA) equipped with a 7683 autoinjector module, a 7683 autosampler module, GC ChemStation Software and a J&W fuse-silica DB-23 capillary column (0.25 mm i.d., 60 m length, 0.25 µm film thickness; Agilent Technologies, Wilmington, Delaware, USA) was used for separating the FAMEs. The oven temperature was set at 130°C for 5 minutes, ramped to 240°C at 40°C/min and then held there for 15 minutes. Both injector and flame ionization detector were set at 250°C. Ultra-High Pure (UHP) helium was used as a carrier gas (2.7 ml/min). FAMEs were identified by comparison of their retention times to those of authentic standard mixtures (GLC 458 and GLC-463; Nu-Check Preps Inc., Elysian, MN, USA). The area under each peak was calculated on a percentage basis using methyl heptanoate as the internal standard.

Statistical Analysis: Effects of muscle type (2, LL and SM), injection treatment (4, injected A, injected B, injected C and non-injected) and cooking method (2, dry- and moist-heat) on the color, cooking yield, tenderness and proximate composition were analyzed by analysis of variance using the General Linear Model procedures of the SPSS statistical package (SPSS, 1999). Fatty acid composition of non-injected raw elk meat was determined and compared between muscle types only. For this study, eight paired venison loin and top round were used.

Results:

The average yield achieved for injected sections in this trial was 109.6%. Due to injection of phosphates, the pH of the injected muscle sections was higher (5.6 to 5.7, depending on the concentration of phosphates in the marinade) compared to control samples (5.4).

Colour Appraisal

Similar to most game animals, elk meat appears darker than meat from domestic species. It has a negligible amount of intramuscular fat, which could be one of the reasons for its darker appearance. In the present study, elk meat bloomed quickly with a dark red colour, but it tended to loose its brightness readily on storage. The ability of different muscles to resist metmyoglobin formation during aerobic storage varies greatly and depends upon the species in question, anatomical location within the carcass and most importantly variations in the rate of myoglobin oxidation and the ability of muscle to consume oxygen; *i.e.*, muscles with high activities of oxygen-utilizing enzymes, which allow little penetration of oxygen into the tissue, tend to discolour more rapidly. In this experiment, isobestic wavelengths observed for elk meat were at 485 nm (oxy and metmyoglobin), 520 nm (all three forms), 590 nm (oxy and deoxymyoglobin) and 605 nm (deoxy and metmyoglobin) compared to those reported for beef at 474, 525, 572 and 610 nm, respectively.

The colour of steaks from LL was more appealing compared to steaks obtained from SM. This visual observation was supported by HunterLab values (L*a*b* values), where a* values from LL steaks were significantly ($P<0.05$) higher compared to SM steaks (Fig. 1.2.1). There was no marked difference in HunterLab values between injected and non-injected steaks.

In the simulated retail display case, the elk steaks held a bright red colour for 2 days, but on the third day they began to turn brown and by the fourth day onwards, a greenish discoloration was evident. From day 0 to day 2, the decline in colour values was quite evident, but from that point on the change was minimal (Fig. 1.2.2). In total, the change in colour was monitored for 5 days but by day 5, all steaks were grossly discoloured. The colour stability of elk steaks was very low similar to that observed for bison steaks in the previous study. Additional research on the colour chemical/biochemical stability of meat from these species to help address the reasons behind this aspect is recommended.

As expected, metmyoglobin formation increased, while oxy and deoxymyoglobin proportions decreased with increasing storage time; however, these changes were most pronounced between day 0 and day 1 (Fig. 1.2.3) and corresponded to the changes observed in HunterLab values. The relative amounts of the three forms of myoglobin depend upon a

number of factors such as the availability of oxygen, the autoxidation rate of myoglobin and the metmyoglobin reducing capacity, thickness of the different myoglobin layers, and the depth of light penetration during colour measurements. Prolonged storage at chill temperatures can cause partial dehydration or desiccation of the meat surface, which tends to accelerate metmyoglobin formation.

Tenderness evaluation

The cooking yield for the roasts obtained from the injected (*i.e.*, marinated) muscle sections was higher compared to steaks from control non-injected sections when cooked by dry- or moist-heat (Tables 1.2.3 and 1.2.4). The injected roasts also took less time to reach the desired endpoint temperature (71°C) compared to control ones. The cooking yield was influenced markedly by the method of thermal processing (*i.e.*, dry- or moist-heat). Cooking by moist-heat gave significantly lower percent cooking losses compared to that by dry-heat. This observation was supported by higher EM values for injected roasts relative to control samples (Tables 1.2.3 and 1.2.4).

Injected roasts had lower shear force values (48.5 N) compared to control ones (62.4 N). When tenderness (shear force values) was evaluated between three types of injected roasts. Injected C (0.3% sodium tripolyphosphate) had lower shear force values compared to injected B (0.2% sodium tripolyphosphate) and A (0.1% sodium tripolyphosphate), but these treatments did not differ significantly ($P<0.05$) (Fig. 1.2.4). Cooking yields for the roasts obtained from the injected B (0.2% STPP) and C (0.3% STPP) muscle sections were significantly ($P<0.05$) greater than those from injected A (0.1% STPP) and control non-injected sections when cooked by either dry- or moist-heat. LL roasts were more tender compared to SM roasts (Fig. 1.2.5). Moist-heat cooking proved to be better than that of dry-heat cooking when shear force values were compared (Fig. 1.2.6). This observation was well supported by the values obtained for EM (Tables 1.2.3 and 1.2.4).

Proximate Composition

Data on proximate composition of non-injected fresh and cooked samples from elk LL and SM roasts have been presented in Tables 1.2.1 and 1.2.2. The composition of these muscles shows that elk meat is high in protein and very lean; however, LL had a significantly higher fat content (2.33%) compared to SM (0.88%). Lower moisture content for cooked samples (because of losses during cooking) was responsible for the increased percent protein, fat and ash contents when these values were compared to fresh ones.

Fatty acid profiles

Determination of fatty acid composition of muscle and adipose tissue has been the subject of numerous investigations, in large part because of the influence that dietary fat has on human blood lipids and the various effects blood lipids have on cardiovascular health. The predominant unsaturated fatty acids (UFA) identified in elk meat were as follows: oleic (18:1 ω9) > linoleic (18:2 ω6) > arachidonoic (20:4 ω6) > palmitoleic (16:1 ω7) > α-linolenic acid (18:3 ω3). Stearic (18:0), palmitic (16:0) and myristic (14:0) acids were the dominant saturated fatty acids (SFA) detected. Overall elk meat had 46% SFA and 54% UFA (32% monounsaturated fatty acids, MUFA and 22% polyunsaturated fatty acids, PUFA) (Fig. 1.2.7). In the present study, the ratio of PUFA:SFA for elk meat was greater than those reported for beef and lamb (0.11 and 0.15, respectively). Plasma cholesterol concentration is influenced by the fatty acid composition of dietary fat; high dietary levels of saturated fatty acids increase plasma cholesterol levels. Therefore, higher values for the PUFA:SFA ratio indicate that elk meat might be healthy, especially in relation to cardiovascular disease; this could be a positive marketing asset for elk meat.

The findings of the present study suggest that marination by injection has a great deal of potential in improving the tenderness and juiciness of elk meat. Although these findings need to be supported by consumer panel and sensory data, at this stage the 0.2-0.3% level of sodium tripolyphosphate in the finished marinated product seems to be optimum for improving the tenderness of elk roasts. Processors can successfully use this technology to produce value-added meat products from specialty livestock.

People involved:

- **J.S. Dhanda**
- **W.P. Rogers**
- **P.J. Shand**
- **H.D. Silcox**
- **R.T. Sefton**
- **M. Dwaoraczek**

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Note: A research paper from this study has been submitted for consideration of publication to the *Journal of Food Science*. Currently the manuscript is under review. See Appendix 4 for conference presentations.

Table 1.2.1. Proximate composition (Mean ± SD) of fresh and cooked roasts from elk *semimembranosus* (SM) muscle

Sample type	Proximate composition (%)			
	Moisture	Crude Protein	Fat	Ash
Fresh	74.01±0.52	24.02±0.70	0.88±0.38	2.25±0.36
Cooked				
Dry-heat	65.44±1.17	31.96±1.66	1.12±0.47	2.89±0.74
Moist-heat	68.41±1.89	28.81±1.21	1.51±0.52	2.25±0.65

Table 1.2.2. Proximate composition and pH (Mean ± SD) of fresh and cooked roasts from elk *longissimus lumborum* (LL) muscle

Sample type	Proximate composition (%)			
	Moisture	Crude Protein	Fat	Ash
Fresh	72.24±0.53	24.36±0.48	2.33±0.67	2.15±0.67
Cooked				
Dry-heat	64.47±1.20	31.65±1.66	2.56±0.63	2.39±0.61
Moist-heat	67.95±0.72	29.79±1.25	2.64±0.94	2.41±0.85

Table 1.2.3. Cooking parameters (Mean ± SD) of elk roasts cooked by dry-heat

Sample types	Parameters		
	Cooking yield (%)	Cooking time (min)[a]	EM (%)[b]
Control	74.80±2.28	22.67±2.60	16.56±3.90
Injected A[c]	77.20±2.39	19.29±2.45	18.78±2.07
Injected B[c]	78.80±1.44	18.93±2.67	18.48±2.82
Injected C[c]	79.35±2.47	18.95±3.25	16.89±4.05

[a]Cooking time/100g (min), time taken by each roast to reach 71°C from 15°C internal temperature / weight of the roast x 100
[b]EM, Expressible moisture
[c]Injected A (0.5% sodium chloride and 0.1% sodium tripolyphosphate), Injected B (0.5% sodium chloride and 0.2% sodium tripolyphosphate), and Injected C (0.5% sodium chloride and 0.3% sodium tripolyphosphate).

Table 1.2.4. Cooking parameters (Mean ± SD) of elk roasts cooked by moist-heat

Sample types	Parameters		
	Cooking yield (%)	Cooking time (min)[a]	EM (%)[b]
Control	83.98±3.13	17.13±3.01	25.63±3.26
Injected A	84.12±2.93	16.85±3.82	25.05±3.12
Injected B	86.48±2.70	16.28±2.97	24.92±2.11
Injected C	88.09±2.78	14.85±3.03	23.49±3.07

[a]Cooking time/100g (min), time taken by each roast to reach 71°C from 15°C internal temperature / weight of the roast x 100
[b]EM, Expressible moisture

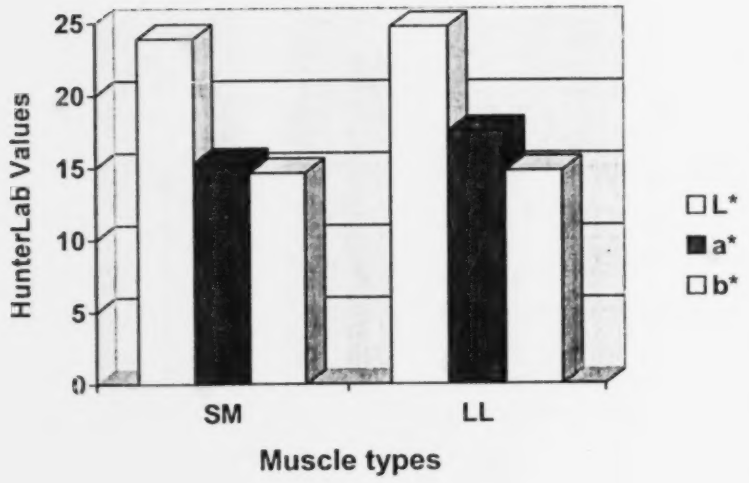

Fig. 1.2.1. HunterLab (L*, a*, b*) values of elk *semimembranosus* (SM) and *longissimus lumborum* (LL) steaks stored at 3±1°C in a retail display case.

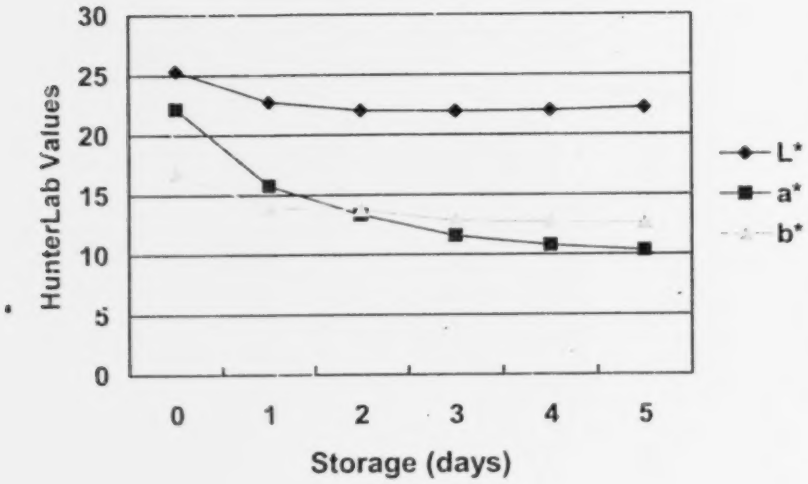

Fig. 1.2.2. Effects of storage 3±1°C in a retail display case on HunterLab values of elk *semimembranosus* and *longissimus lumborum* steaks.

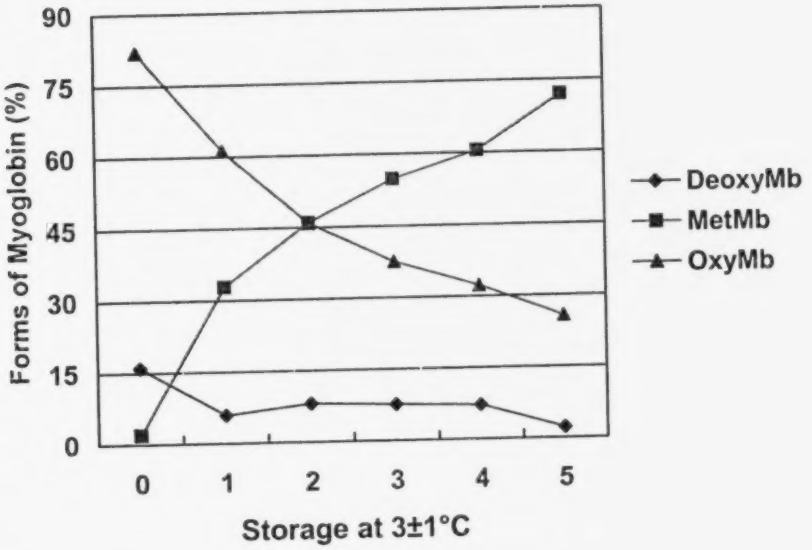

Fig. 1.2.3. Effect of storage on the proportion of three forms of myoglobin (DeoxyMb, deoxymyoglobin; MetMb, metmyoglobin and OxyMb, oxymyoglobin).

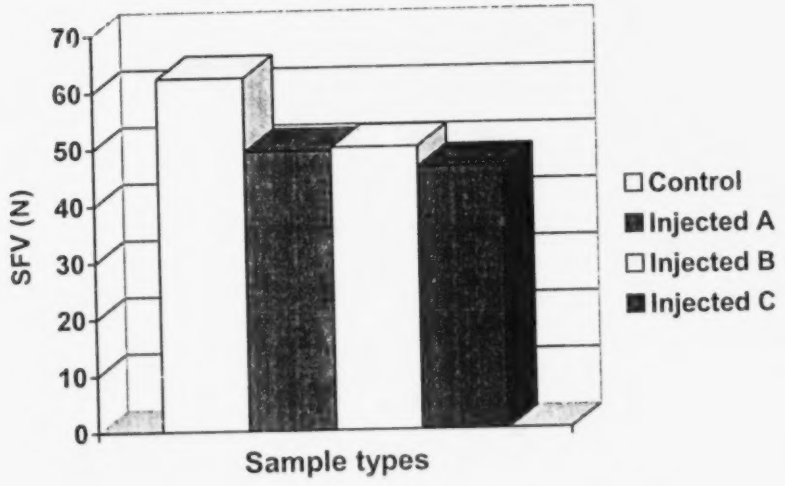

Fig. 1.2.4. Shear force values of control and injected roasts. The brine solutions formulated to achieve the following concentrations of salt and phosphate in the finished marinated product: Injected A (0.5% sodium chloride and 0.1% sodium tripolyphosphate), Injected B (0.5% sodium chloride and 0.2% sodium tripolyphosphate), and Injected C (0.5% sodium chloride and 0.3% sodium tripolyphosphate).

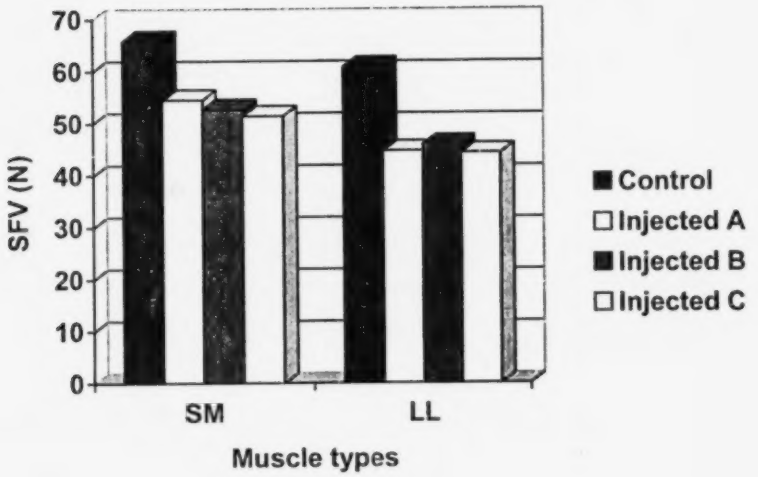

Fig. 1.2.5. Shear force values of control and injected roasts from elk *semimembranosus* (SM) and *longissimus lumborum* (LL) roasts. The brine solutions formulated to achieve the following concentrations of salt and phosphate in the finished marinated product: Injected A (0.5% sodium chloride and 0.1% sodium tripolyphosphate), Injected B (0.5% sodium chloride and 0.2% sodium tripolyphosphate), and Injected C (0.5% sodium chloride and 0.3% sodium tripolyphosphate).

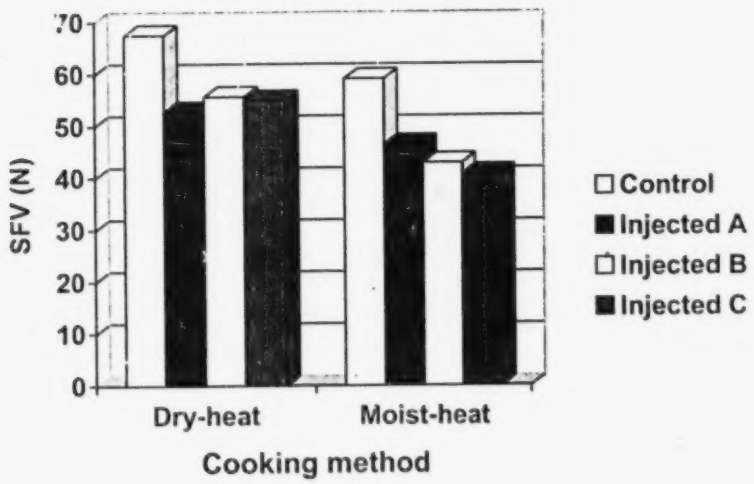

Fig. 1.2.6. Effect of cooking method on shear force values of control and injected elk roasts. The brine solutions formulated to achieve the following concentrations of salt and phosphate in the finished marinated product: Injected A (0.5% sodium chloride and 0.1% sodium tripolyphosphate), Injected B (0.5% sodium chloride and 0.2% sodium tripolyphosphate), and Injected C (0.5% sodium chloride and 0.3% sodium tripolyphosphate).

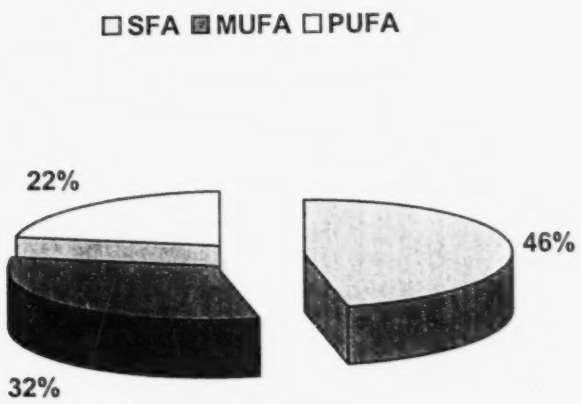

Fig. 1.2.7. Fatty acid composition of elk meat. SFA, saturated fatty acids; MUFA, monounsaturated fatty acids and PUFA, polyunsaturated fatty acids.

Activity 1.3: cooking regime	Palatability of bison and beef top rounds: Effects of marination and

Background and Objectives:

The adaptation of pumping technologies to produce "moisture-enhanced" fresh meat products has evolved rapidly to satisfy consumer tastes. Most pumping solution contain salt, phosphate and flavouring agents. These components help in stabilizing colour, improving water-holding capacity and also in improving sensory characteristics. Moisture-enhancement through mechanical injection of pump-solutions has been successfully employed for bison top round under this program. It has been demonstrated that conventional dry-heat cooking results in less tender meat from high connective tissue cuts such as those from top round than from low-connective tissue cuts such as those from loin muscles. Collagen, the main connective tissue protein, is mainly responsible for texture differences between muscles. During cooking, denaturation of the insoluble portion of collagen is temperature dependent; it is for this reason that reaching the optimal temperature and rate of cooking are essential in achieving the right texture for a particular muscle cut. With this background in mind another study was conducted to investigate the effects of marination and different cooking regimes on the cooking yield and palatability of bison and beef top round roasts.

Materials and Methods:

Eight paired bison and beef top rounds (*semimembranosus*, SM, muscle) were obtained and each SM muscle was divided into four equal portions (800±50g) before processing. Portions from one side were injected to achieve 20% extension by weight and 0.5% NaCl and 0.3% STPP in the finished marinated product, while those from the other side were kept as non-injected control. The marinated product yields based on the green weight were calculated after injection. Samples were also collected from each section for pH, expressible moisture and proximate composition analysis.

pH analysis and proximate chemical composition: pH and chemical composition were determined as described in Activity 1.1.

Cooking of steaks and evaluation of tenderness: After marination, roasts were steam-cooked in a smokehouse (single truck Alkar smokehouse, Alkar, Lodi, WI, USA) to a final internal temperature of 71°C using the following four cooking regimes:

- cooking at a constant smokehouse temperature of 75°C (**C**),
- similar to control cooking except holding the roasts at an internal temperature of 50°C for 45 minutes (**H45**),
- similar to control cooking except holding the roasts at an internal temperature of 50°C for 90 minutes (**H90**) and
- finally cooking at 55°C and raising the smokehouse temperature by 5°C every hour till the internal temperature of 71°C was reached (**UP**).

Before thermal processing, thermocouples were inserted into the geometric centre of each roast. The temperatures of the smokehouse and roasts were monitored by these thermocouples. The probes were attached to a scanner and a computer that recorded the change in temperature every 30 seconds. The cooking time and yield of the roasts were also recorded.

After cooling down to an internal temperature of 50°C, cooked roasts were stored at 4°C overnight. The following day, 6-8 cores (1.27 x 1.27 x 3.81 cm) were removed from each roast parallel to the direction of the muscle fibres. These cores were allowed to equilibrate at room temperature for an hour before the measurements (shear force values) were taken. Tenderness and expressible moisture (EM) measurements were made as described in Activity 1.1.

Purge during storage: Three 3 mm slices of roast were vacuum-packed (-0.8 bar) in each of 3 polyethylene bags and stored in an upright position in a walk-in cooler at 4°C. Purge was determined by reweighing blotted slices following 3 weeks of storage, and expressed as a percentage of the initial slices weight.

Statistical analysis: Statistical analysis was performed using the SPSS statistical package (SPSS 1999). Eight paired bison and beef top rounds were used for the study. Data were analyzed by analysis of variance as a 2x4 factorial design with two meat sources (beef and bison), two marination treatments (injected and non-injected), and four cooking regimes (C, H45, H90 and UP) as main effects.

Results:

As expected, bison SM muscle samples were leaner compared to beef samples but there were no significant differences between these two species in terms of protein content (Table 1.3.1). Similar to the findings from the previous studies, injection by marination helped in improving the yield and tenderness of bison and beef SM muscle. The cooking yield for injected samples (78%) was significantly ($P<0.05$) higher compared to non-injected controls (68%). When comparing beef and bison samples, injected bison SM muscle roasts had lower cooking losses than injected beef ones; the cooking yields of control samples from these two species did not differ (Fig. 1.3.1). Out of the four cooking regimes employed, H 45 (holding meat samples at 50°C for 45 minutes) produced a better cooking yield for both injected and non-injected roasts than other regimes tested (Fig. 1.3.2 and 1.3.3). Beef SM muscle was more tender than bison SM muscle; however, marination by injection was able to significantly ($P<0.05$) reduce the shear force values (made it more tender) of SM roasts from both species (note: shear force values of 82N in control samples was decreased to 63N in injected ones) (Fig. 1.3.4). Cooking regimes *i.e.*, H45, H90 and UP, produced significantly ($P<0.05$) tenderer roasts compared to control steam cooking (Fig. 1.3.5 and 1.3.6), these results were more marked for injected steaks, which again emphasize the importance of moisture-enhancement for less-tender cuts. However, there was no significant difference in shear force values between H45, H90 and UP cooking regimes. Owing to a higher cooking yield, injected bison SM muscle roasts had greater expressible moisture and purge (after 3 weeks of storage) compared to those from beef (Fig. 1.3.7 and 1.3.8).

Out of the four cooking regimes tested, H45, H90 and UP produced significantly lower shear force values (more tender) than the control, but based on the cooking yield, H45 had an edge over the other regimes employed.

Note: A research publication from this study is in preparation.

People Involved:

- **J.S. Dhanda**
- **Z. Pietrasik**
- **P.J. Shand**
- **R.B. Pegg**
- **H.D. Silcox**
- **R. T. Sefton**

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SPSS. 1999. SPSS base 10.0 user's guide. Chicago: SPSS Inc.

Table 1.3.1. Proximate chemical composition (Mean ± SD) of fresh and trimmed beef and bison SM

	Proximate chemical composition (%)			
Species	Moisture	Protein	Fat	Ash
Beef	73.4±0.67	22.3±0.42	2.6±0.11	1.2±0.08
Bison	74.5±0.59	22.5±0.46	1.0±0.14	1.1±0.07

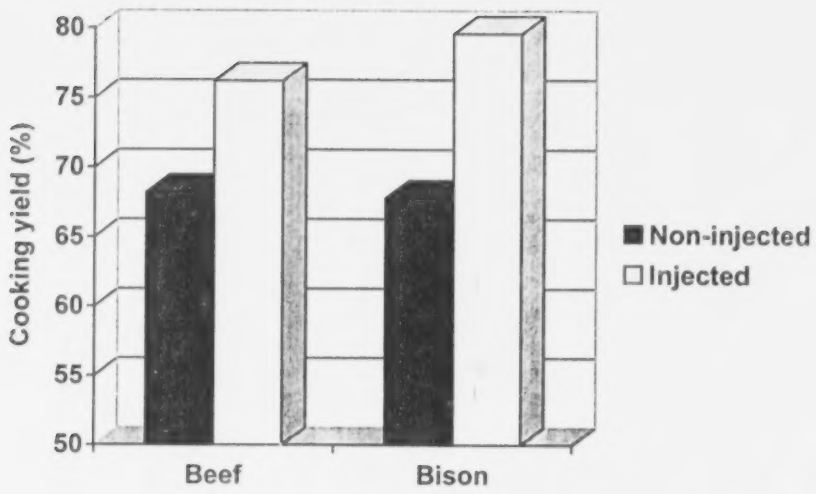


Fig. 1.3.1. Effect of marination on the cooking yield of beef and bison SM muscle roasts.

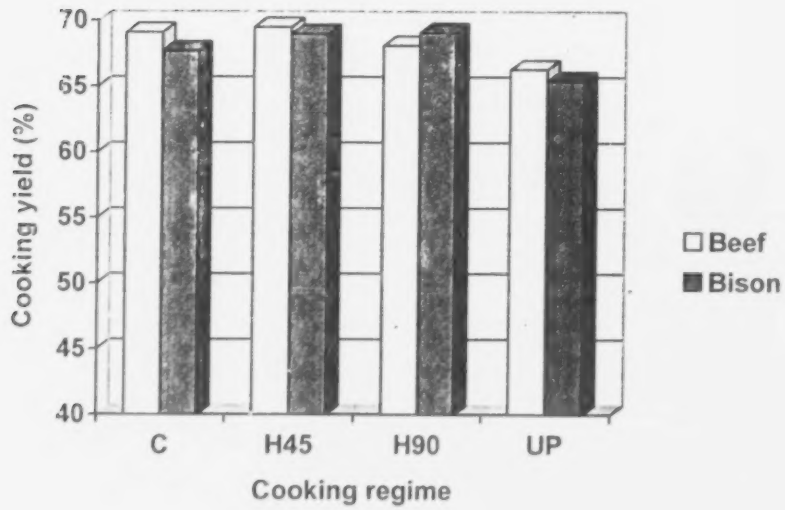


Fig. 1.3.2. Effect of cooking regime on the cooking yield of non-injected beef and bison SM muscle roasts.

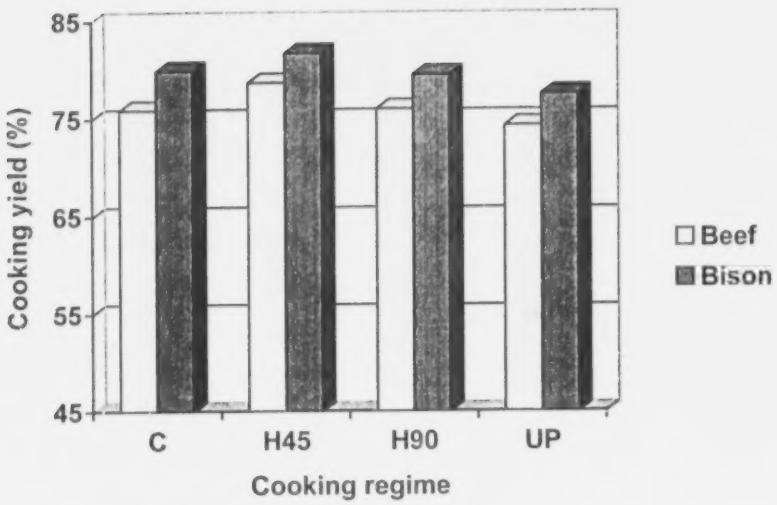


Fig. 1.3.3. Effect of cooking regime on the cooking yield of injected beef and bison SM muscle roasts.

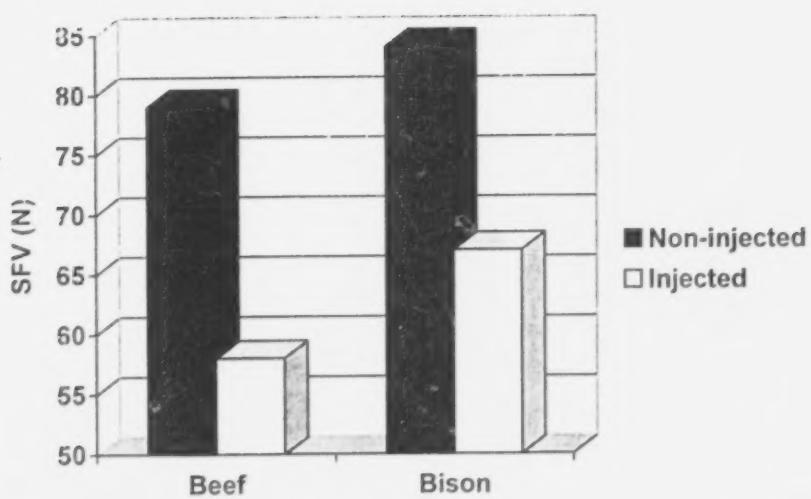


Fig. 1.3.4. Effect of marination on shear force values (SFV) of beef and bison SM muscle roasts.

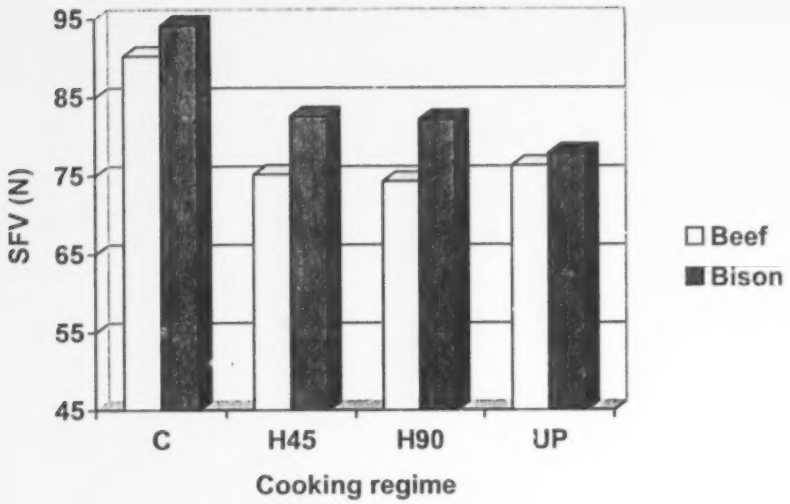


Fig. 1.3.5. Effect of cooking regime on shear force values (SFV) of non-injected beef and bison SM roasts.

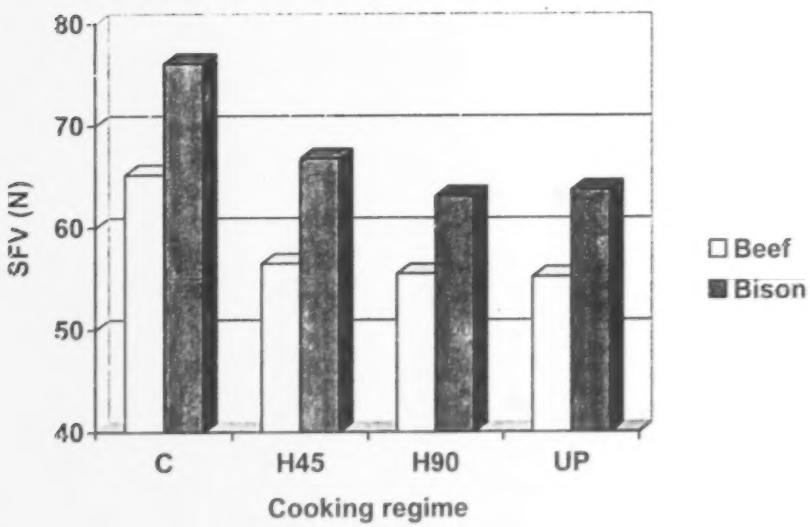


Fig. 1.3.6. Effect of cooking regime on shear force values (SFV) of injected beef and bison SM muscle roasts.

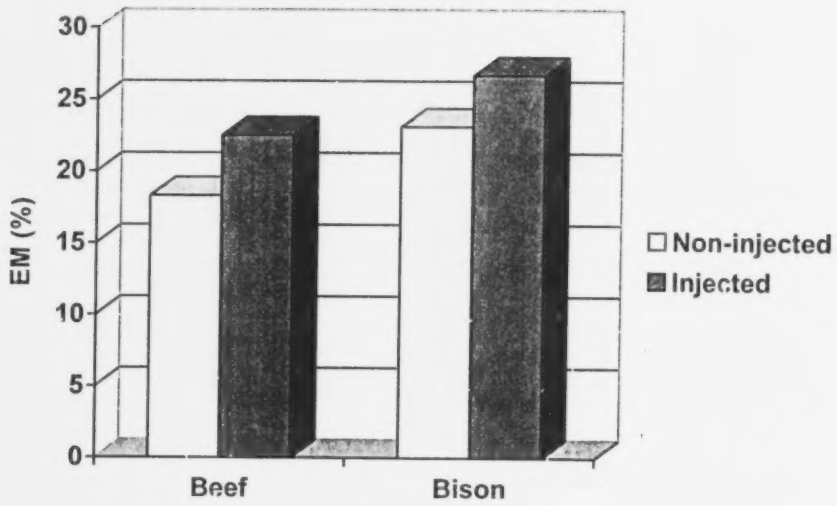


Fig. 1.3.7. Effect of marination on expressible moisture (EM) of cooked beef and bison SM muscle roasts.

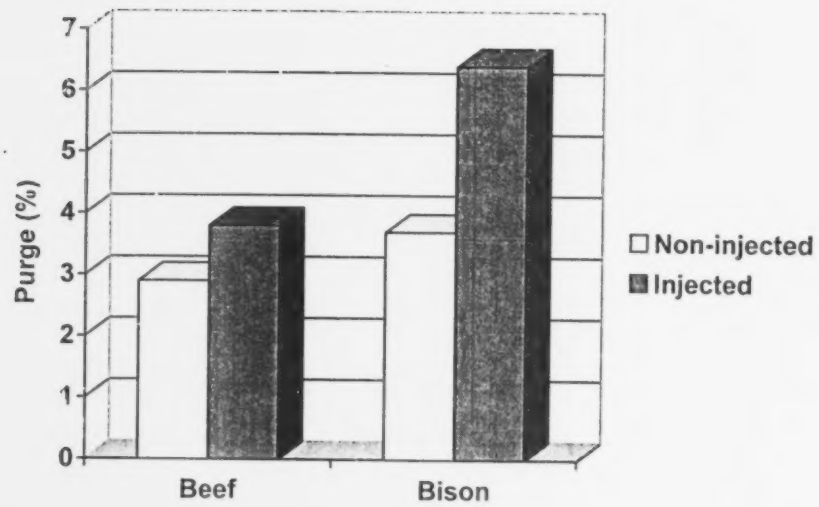
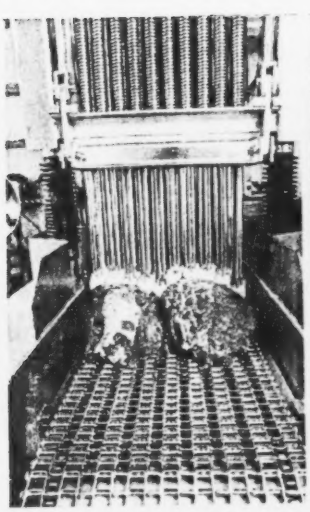
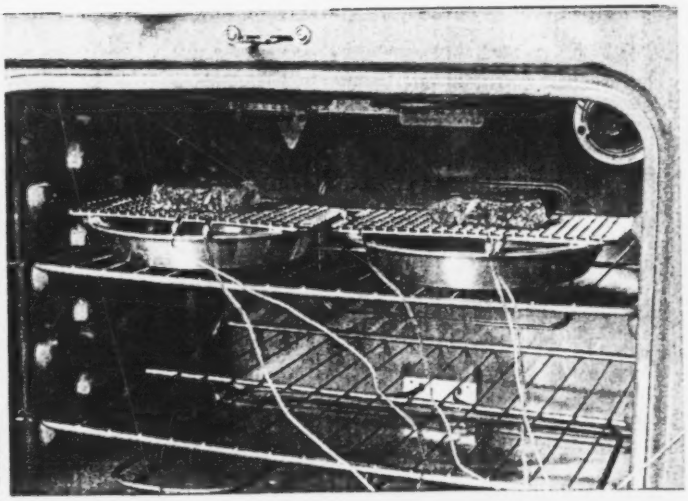


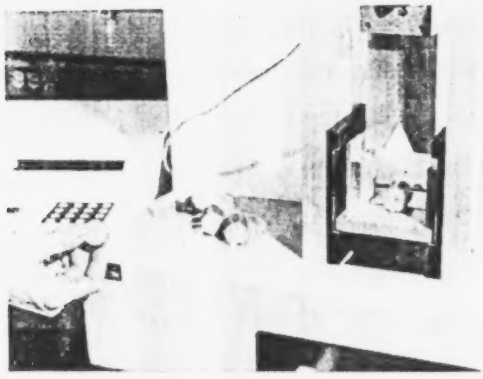
Fig. 1.3.8. Effect of marination on purge of cooked beef and bison SM muscle roasts.

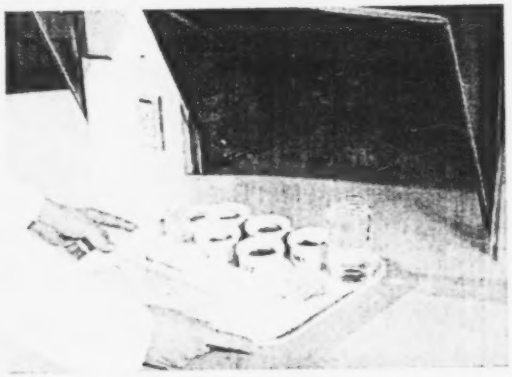




OBJECTIVE 1

To improve the palatability and to value-add lesser cuts of meat from specialty livestock by existing and possibly





Activity 2.1: Effects of Antioxidants to Enhance the Red Colour of Elk Meat

Background and Objectives:

The colour of meat is the single most important factor that influences the buying decision of a consumer. In red meat, the bright, cherry red colour is normally used as an indicator of freshness by the consumer. Unfortunately, this bright red colour fades as an unacceptable brown colour with time. Meat colour is largely a contribution of myoglobin, a heme protein found in muscles. In well-bled muscle tissue, myoglobin constitutes 80-90% of the total pigments present; other present heme proteins such as hemoglobin and cytochromes contribute little to the colour of fresh meat. The myoglobin "pigment" has a purplish red colour and this is the colour of freshly cut meat. When a freshly cut surface of meat comes in contact with air, myoglobin is oxygenated and converted to oxymyoglobin, which gives meat a bright cherry red colour. If only small quantities of oxygen are present, such as in a partial vacuum or a sealed semi-permeable package, myoglobin is converted to metmyoglobin through oxidation giving the meat a brown appearance. Formation of this brown colour is a serious problem in merchandising meat because most consumers associate it with a product that has been stored too long. Elk meat is traditionally viewed as having a dark brown colour. This colour, similar to that resulting from metmyoglobin formation, is unacceptable to retail consumers who are conditioned to the bright cherry red colour of beef. The colour of the meat can be controlled or improvised if the factors influencing it are better understood. Keeping this in mind, a preliminary research trial was carried out to determine the effects of incorporating antioxidants/chelators such as sodium ascorbate, rosemary extract and sodium tripolyphosphate in a marinade to enhance the red colour of elk meat.

Materials and Methods:

The experiment was conducted on previously frozen loin (*longissimus dorsi*) and sirloin (*gluteus medius*) cuts of meat obtained from a 4 year old male. No other history on the animal was available. The meat was cut into 0.4 cm slices that were trimmed of excess fat and subdivided into two. The meat was then weighed and treated with marinade (at 10% of meat weight) and vacuum packaged in a low oxygen permeable bag. The marinades were prepared on a weight to weight basis. For the first experiment, each marinade was

formulated by weighing out a combination of 0.22 g (0.55%) of sodium ascorbate, 0.22 g (0.55%) of rosemary extract, and/or 1.2 g (3.0%) of sodium tripolyphosphate (STPP), followed by the addition of enough distilled water to a mass of 40 g. For the second experiment, the concentration of sodium ascorbate was changed and it was employed at the following levels: 0.132 g (0.33%), 0.22g (0.55%) and/or 0.308 g (0.77%) to deliver 300, 500 and 700 ppm solutions of sodium ascorbate to the meat slices.

Experiment 1: Loin: The following treatments were applied: 1) control – water; 2) sodium ascorbate; 3) Guardian® rosemary extract; 4) Herbalox® rosemary extract; 5) STPP; 6) sodium ascorbate + Guardian® rosemary extract; 7) STPP + Guardian® rosemary extract; 8) sodium ascorbate + STPP; 9) sodium ascorbate + STPP + Guardian® rosemary extract; 10) sodium ascorbate + STPP + Herbalox® rosemary extract; 11) STPP + Herbalox® rosemary extract; and 12) sodium ascorbate + Herbalox® rosemary extract. All extracts were applied at 500 ppm except the STPP, which was applied at a 0.32% concentration.

Experiment 2: Sirloin: For this experiment the concentration of sodium ascorbate was modified. The treatments included: 1) control – water; 2) 300 ppm sodium ascorbate; 3) 500 ppm sodium ascorbate; 4) 700 ppm sodium ascorbate; 5) 500 ppm Guardian® rosemary extract; and 6) 500 ppm sodium ascorbate + 500 ppm Guardian® rosemary extract.

For each experiment the sealed packages (*i.e.*, with meat slices and marinade) were tumbled with ice in a meat tumbler for 10 minutes. Meat slices were removed from the vacuum packages and weighed to determine pick up. These slices were then placed on styrofoam trays and wrapped with oxygen permeable film. The samples from the first experiment were stored in a retail case display cabinet at 4°C with a light intensity of 475±27 lx. For the second experiment, the storage temperature was 2±1°C and the light intensity was 806±70 lx. All samples were assessed for colour change visually and with a HunterLab Colorimeter (MiniScan XE). Samples were examined every 24 hours for 8 days.

Summary of Results:

It was observed that the sodium ascorbate was the most successful at enhancing the red colour of the elk meat, as determined by HunterLab a* values and a visual panel. The samples containing sodium ascorbate gave the best red colour scores and preserved the red colour for an additional three to four days. However, the panel was unable to detect

differences in redness between the meat samples marinated in 300, 500 and 700 ppm sodium ascorbate. There were also small improvements in Hunter a* values when the Guardian® rosemary extract was included in the marinade, but the visual panel did not detect these improvements. This preliminary trial was conducted only on one animal, just to get some preliminary on the aspects of colour stability and means of improving it in elk. These findings helped us in designing future research projects.

People involved:

- **S.L. Parchewski**
- **P.J. Shand**
- **D.D. Pobereznek**
- **R.B. Pegg**
- **H.D. Silcox**
- **C. Yu**

Activity 2.2: Effects of Vacuum and Modified Atmosphere Packaging on Colour and Shelf-stability of Bison and Beef Steaks

Background and Objectives:

Maintaining the quality and appearance is essential during the distribution and merchandising of perishable food products like meat. The only criterion consumers have at the point of purchase when selecting meat cuts is visual appearance. To prevent product shrinkage and delay the onset of its deterioration, optimum storage temperature and appropriate packaging is necessary during retail display. There are many packaging options available in the market; knowledge of the characteristics of packaging materials and systems along with other factors influencing the keeping quality of meat in question is essential when making selection of appropriate packaging. Vacuum and modified atmosphere packaging with one or more gases are being used in the industry to design different conditions to maximize the shelf-life of meat and to promote desired product characteristics. The most commonly used gases for packaging of meat are carbon dioxide (CO_2), nitrogen (N_2) and oxygen (O_2). As experienced in the bison marination study, the colour stability of previously frozen bison steaks was very low in the retail case. To improve this situation, it was decided to explore the effects of vacuum and modified atmosphere packaging and different storage conditions on the colour stability of bison steaks in the retail display case and to further compare these with that of beef steaks. Results from a preliminary trial suggested that the colour of bison steaks (even fresh, but aged 10 days) did not last more than 2 days in the retail case; however, encouraging results (colour shelf life extended up to 4 days) were achieved from steaks packaged under a vacuum and in a modified atmosphere (75-80% O_2). With this in mind, a study was designed to assess the influence of injection, packaging and storage conditions on the colour stability of beef and bison steaks in the retail display case.

Materials and methods:

Experimental Design: Fresh beef and bison loins (*Longissimus lumborum*, LL - 4 each) were procured from local sources. Each LL was divided into two almost equal sections. One of these sections was injected with brine containing sodium chloride and STPP (0.5% and 0.3%, respectively in the finished product) to achieve 20% extension by weight, while the

other side was kept as non-injected control. Then each of these loins was divided into as many steaks (1" thick) as possible. These steaks were randomly allocated to storage atmospheres, storage temperatures and storage interval subgroups (Table 2.2.1). The number of steaks mentioned below is for one group (beef or bison) only and an equal number of steaks was used for the other group.

Table 2.2.1. Experimental design (allocation of LL steaks to each treatment prior to the retail display)

Storage atmosphere	Storage temperature	Storage interval (weeks)			
		0	1	2	3
Over-wrap (OP)	+4°C	8[a]	Straight to display unit		
Vacuum packaging (VP)	+4°C		8	8	8
	-1°C		8	8	8
70% O_2, 30%CO_2 (MAP)	+4°C		8	8	8
	-1°C		8	8	8

[a]Number of steaks per treatment (half from control and half from injected group).

Packaging and storage: Each steak was transferred to a styrofoam tray and then over wrapped with an oxygen permeable film. The steaks (8) assigned for fresh display (OP) were placed in the retail display case. The steaks (48) for vacuum packaging (VP) treatment were individually packaged in ethylene/vinyl acetate copolymer poly-vinylidene-chloride (PVDC) laminate bags. After making two holes through the over-wrap film for free exchange of gases, the steaks (48) for modified atmosphere packaging (MAP) were put into Cryovac B series bags (oxygen transmission rate of 3.6 $cm^3/m^2/24h$ at 40°F), headspace evacuated and then filled with a mixture of 70% O_2 and 30% CO_2 and sealed using a modified Fresh VAC machine (CVP System Inc., IL, USA). OP, VP and MAP steaks were stored at designated temperatures and for set periods (Table 2.2.1).

Sampling of residual oxygen: To confirm that the packaging machine was performing to specification and also after each storage period to verify the pack integrity, MAP packs were randomly sampled for their oxygen content, which was carried out using a MOCON HS750 Oxygen Headspace Analyzer (Modern Controls Inc., Minneapolis, MN, USA).

Retail display conditions and colour appraisal: After removal from the main packaging following the designated storage interval, steaks were re-packaged on a styrofoam tray with

an oxygen permeable film and then placed in the retail display case. The temperature of the retail case was 3±1°C and the fluorescent lamps used during storage were F40SPEC30 (PHILLIPS). The light intensity was monitored throughout the trial period with a Lutron LX-101 Digital Lux Meter. Light intensity was measured to be 975 lx (950-1000 lx) on average and was on continuously, 24 hours/day. The changes in colour were determined using a HunterLab MiniScan XE (HunterLab machine was set at L*a*b*, observer 10, illuminant A). The colour was read daily at the same position (marked on the steak) and two readings at right angle to one other were recorded for each steak. Furthermore, the change in colour was observed visually.

pH analysis: pH was determined according to that described in Activity 1.1.

Thiobarbituric acid reactive substances (TBARS): These were determined by the trichloroacetic /phosphoric extraction method described in detail by Pegg (2001) and expressed as mg malondialdehyde equivalents per kg of fresh meat sample.

***Aerobic plate counts*: Slices of meat (3 cm x 3 cm) were aseptically obtained from the steaks. Each slice was placed in a stomacher bag and homogenised for 2 min after adding 90 ml of dilution solution (8.5 g NaCl and 1 g peptone in 1 L of deionized water). One ml of homogenate was added to a test tube filled with 9 ml of dilution solution and plate counts were done by serial dilutions following standard procedures. Standard methods agar (Difco Laboratories, MI, USA) was used as growth media.**

Statistical analysis: Statistical Analysis was performed using General Linear Model procedures of the SPSS statistical package (SPSS 1999). Data were analyzed by analysis of variance with as a factorial split-plot with main plots arranged in a completely randomized design with two meat sources (beef and bison), two marination treatments (injected and non-injected), two packaging types (MAP and VP), two storage temperatures (4 and –1°C) and three storage intervals (1, 2 and 3 weeks) as main effects. The effect of storage in a retail display was also analyzed. The study was repeated and 200 steaks were used for each replication.

Results

Colour stability

As is typical of most game animals, bison meat appears darker than meat from beef. It has a negligible amount of intramuscular fat, which could be a possible reason for its darker appearance. In the present study, bison meat bloomed quickly with a dark red colour, but it tended to loose its brightness readily on storage compared to beef (Fig. 2.2.1). The colour of the muscle tissue is influenced by the amount and chemical state of the myoglobin pigment and by the superficial structure of the meat, which is directly related to its ultimate pH and oxidation/reduction potential. In the absence of oxygen, the pigment is in the form of deoxy or reduced myoglobin that has a purple-red colour. On exposure to air, the pigment is oxygenated to form oxymyoglobin, which imparts to the muscle a bright red colour that consumers find attractive. Both deoxy- and oxymyoglobin also react with oxygen to form the oxidized form, metmyoglobin, which has a dull brown colour that consumers associate with a loss in quality. The principal aims in the preservation of chilled meat are the retention of the attractive fresh meat appearance and delay in bacterial spoilage.

HunterLab colour values, especially a* values, are a good indication of the redness of meat; the higher the a* value, the redder the meat. Steaks stored under MAP had higher a* values (brighter red) compared to those stored under vacuum (Fig. 2.2.2). A continued supply of oxygen in the atmosphere (*i.e.*, headspace) was responsible for oxygenation of myoglobin, hence the bright red colour. The ability of different muscles to resist metmyoglobin formation during aerobic storage varies greatly and depends upon the species in question, anatomical location within the carcass and most importantly, variations in the rate of myoglobin oxidation and the ability of muscle to consume oxygen; *i.e.*, muscles with high activities of oxygen-utilizing enzymes, which allow little penetration of oxygen into the tissue, tend to discolour more rapidly. As expected, steaks stored at lower temperature (-1°C) held better colour than those stored at higher temperature (+4°C) (Fig. 2.2.3). Non-injected steaks had higher a* values initially; however, marination did not significantly ($P>0.05$) affect muscle colour after one week of storage (Fig. 2.2.4).

Storage time had an affect on HunterLab values. As expected, there was a gradual loss in colour of steaks with storage in the simulated retail display. In total, the change in colour was monitored for 5 days. The decline in a* values was gradual (from around 28 on first day

to around 12 by day 5) rather than a steep decline as was observed in previous studies, where steaks held a bright red colour for 2 days, but on the third day they started to turn brown and by the fourth day onwards, a greenish discoloration was evident. As mentioned before in previous studies, the colour stability of bison steaks was very low because we could not access fresh meat, and frozen storage deteriorates meat quality to a significant extent, as it relates to colour.

Microbial and chemical quality

Storage temperature is one of the major factors to influence microbial quality of meat products. As expected, microbial load of steaks that were injected and the ones stored at +4°C was higher than non-injected steaks and those stored at -1°C, respectively. Modified atmospheres containing high oxygen concentrations delay the time to spoilage or storage life and colour stability. This was evident from the data obtained on microbial load in the present study (Table 2.2.2). Aerobic counts for steaks stored under MAP were better than those stored under VP; nevertheless, counts from both packaging atmospheres were in the acceptable range. In the present study, a mixture of 70% O_2 and 30% CO_2 was used. The CO_2 in the package atmosphere restricts the growth of aerobic spoilage bacteria, while the elevated O_2 concentration enhances meat colour and extends the stability of oxymyoglobin. Aerobic count increased gradually with storage. The 2-thiobarbituric acid (TBA) test is one of he most widely used methods for measuring the degree of lipid oxidation. In this procedure, malondialdehyde and other secondary oxidation products of unsaturated lipids react with TBA to form a red-coloured chromogen. Owing to a high O_2 concentration and subsequent increased lipid oxidation, MAP steaks had higher TBARS values compared to VP steaks.

A similar trend was observed for beef for the parameters mentioned above (data not shown), however, beef LL steaks were able to retain their bright red colour longer and had a slightly higher although non-significant ($P>0.05$) microbial load compared to bison steaks.

This data suggested that MAP is an excellent option for short-term storage due to its positive effects on meat colour but for longer storage, VP still holds well. Storing meat under vacuum and then placing it under MAP just before retail display might be another option to increase the shelf-life.

People Involved:

- **J.S. Dhanda**
- **Z. Pietrasik**
- **P.J. Shand**
- *R.B. Pegg*
- **H.D. Silcox**
- **R. T. Sefton**
- **M. Dwaoraczek**

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SPSS. 1999. SPSS base 10.0 user's guide. Chicago: SPSS Inc.

Note: A research publication from this study is in preparation.

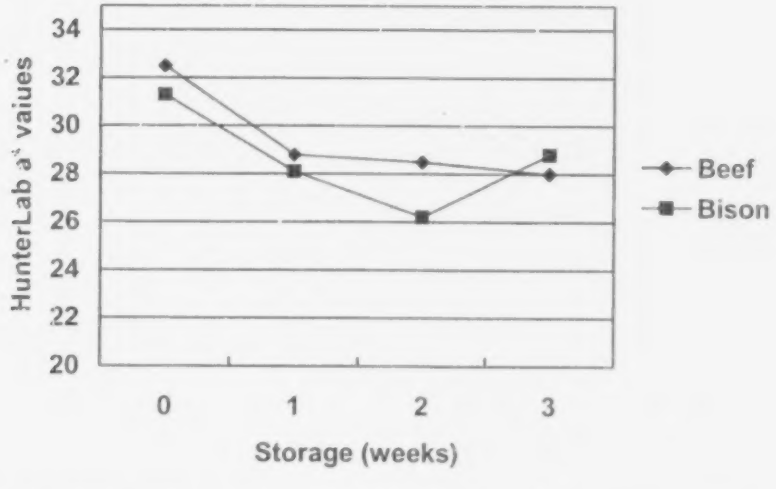


Fig. 2.2.1. Effect of species on HunterLab a* values of fresh *longissimus lumborum* steaks during storage.

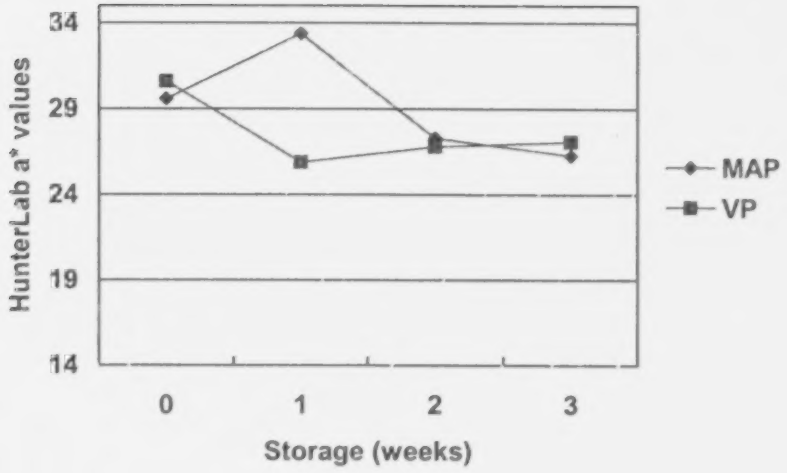


Fig. 2.2.2. Effect of packaging (MAP, modified atmosphere; VP, vacuum packaging) on HunterLab a* values of fresh bison *longissimus lumborum* steaks during storage.

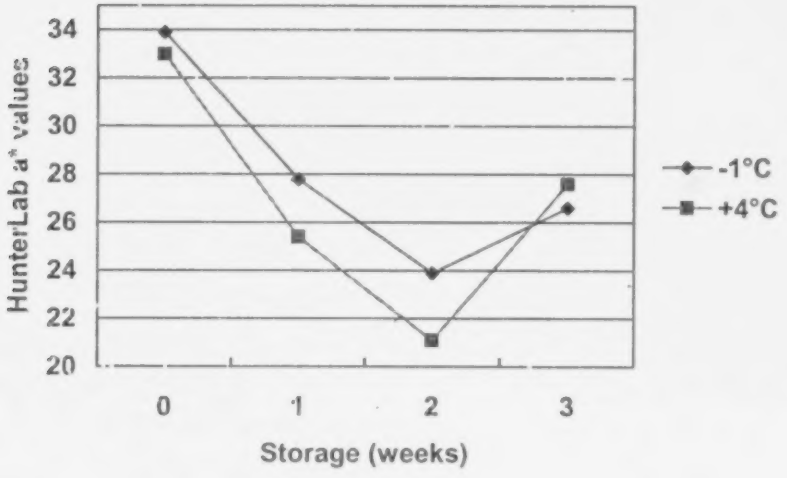


Fig. 2.2.3. Effect of storage temperature on HunterLab a* values of fresh bison *longissimus lumborum* steaks during storage.

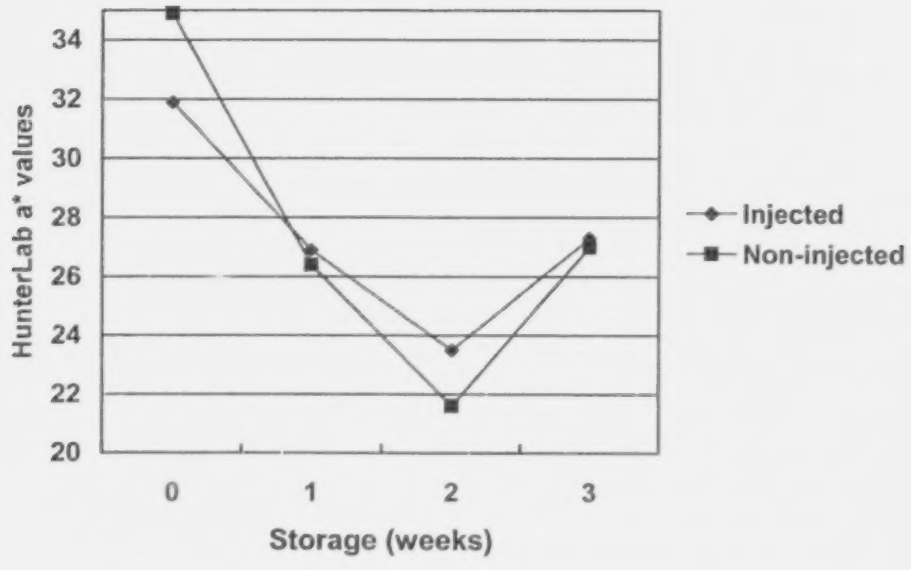


Fig. 2.2.4. Effect of marination on HunterLab a* values of fresh bison *longissimus lumborum* steaks during storage.

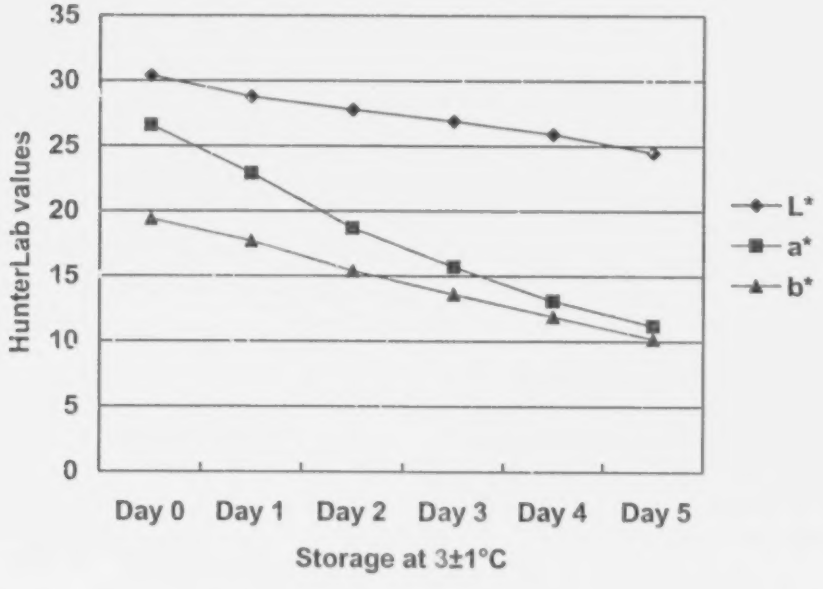
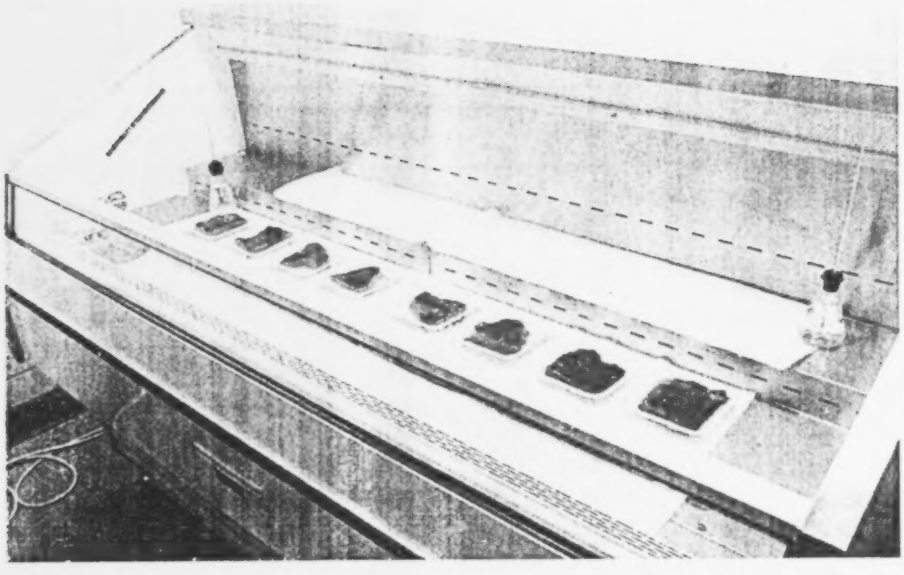


Fig. 2.2.5. Changes in HunterLab colour values (L*, a*, b*) of fresh bison *longissimus lumborum* steaks during storage in retail case.

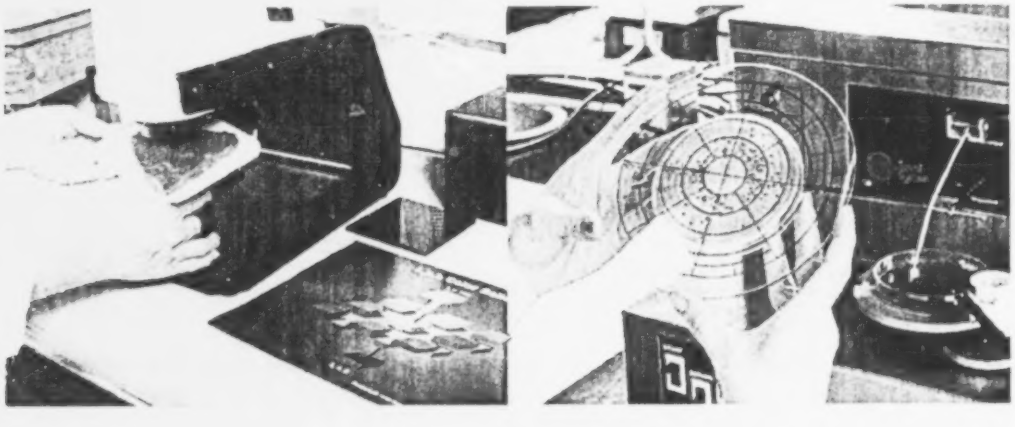
Table 2.2.2. Effects of marination, packaging and storage temperature and duration on pH, bacterial load and TBARS values of fresh bison *longissimus lumborum* steaks

	pH	Aerobic plate count (log CFU/cm^2)	TBARS (mg malondialdehyde equivalents/kg)
Marination			
Injected	5.68	4.64	0.65
Non-injected	5.34	3.63	1.41
Storage temperature			
-1°C	5.55	3.73	0.99
+4°C	5.48	4.84	1.12
Packaging			
Modified atmosphere			
Week 1	5.50	3.19	0.39
Week 2	5.56	3.25	1.16
Week 3	5.76	4.71	1.87
Vacuum			
Week 1	5.54	3.71	0.45
Week 2	5.52	4.88	0.50
Week 3	5.44	5.15	0.71



OBJECTIVE 2

To determine the shelf-life of retail cuts and to address demand for fresh meat delivery into foreign markets so as to prolong meat quality during extended storage via



Activity 3.1: Flavour Characteristics of Meat from Specialty Livestock

Background and Objectives:

Flavour is an important sensory attribute that contributes to the overall acceptability of meat products. Whether we accept or reject a food depends primarily on its flavour. Both desirable and undesirable flavour effects are contemplated: threshold values of different flavour-active compounds have an important effect on the cumulative sensory properties of all foods. Meat from different species provides a major source of protein for most people. Although raw meat has little aroma and only a blood-like taste, it serves as a rich reservoir of non-volatile compounds with taste-tactile properties as well as aroma precursors and flavour enhancers. Non-volatile precursors of meat flavour include amino acids, peptides, reducing sugars, vitamins and nucleotides. Interaction of these components and/or their breakdown products produces a large number of intermediates and/or volatiles that contribute to meat flavour development and aroma generation during heat processing. Lipids also play an integral role in the overall flavour of meat, which is distinct and species dependent. Additionally, the mode of heat processing and the nature of additives used may have a profound effect on the flavour of prepared meats.

The flavour characteristics of some emerging species have not been examined. What is agreed upon, however, is that flavour of thermally processed meats from specialty livestock is not a desirable trait for all consumers. In order to better understand the flavour of some emerging species and to control or mask undesirable components, the constituents that contribute to it must be identified. In order to carry out flavour research, however, two realities are required: first, a means in which to "trap" meat flavour volatiles and second, a way to separate and identify the active compounds.

Materials and Methods:

Meat preparation: Fresh meat from speciality livestock species was acquired whenever possible during the course of this activity. No frozen meat was used. In the case of bison, *longissimus dorsi* muscles were specifically utilized. Meat was trimmed of extraneous fat and connective tissue, and then comminuted by passing it twice through a 1/8 in plate using a Biro grinder/food mixer (AMFG Model 24, Marblehead, OH). Samples from the meat block

(500 g) were transferred to 1-L beakers and mixed with 20% (w/w) distilled water. Meat systems were thermal processed in an 85°C thermostated water bath with occasional stirring until an internal temperature of 74±1°C was reached. Afterwards systems were cooled to room temperature. One sample was immediately taken for volatile extraction while others were covered with Parafilm® and stored in a 4°C refrigerator for 48 hours before volatiles were extracted.

Extraction of Meat Volatiles: A Likens-Nickerson simultaneous distillation-extraction apparatus (Kontes Glass Co., Vineland, NJ) was used to extract aroma volatiles from cooked meat samples (see Fig. 3.1). All cooked meat in the 1-L beaker was transferred to a 3-L round bottom flask and mixed with distilled water at a material-to-solvent ratio of 1:2 (w/w). Ten µL aliquots of the internal standards, tridecane and 2-heptanone or 3-heptanone were added to the meat slurry. A spinbar and several large-sized glass beads were also added to the flask to help prevent bumping. The flask was then placed in a 3-L Glas-Col heating/stirring mantle, which was hooked up to a Glas-Col StirContol II and a PowrTrol controller (VWR International, Mississauga, ON), and then connected to the Likens-Nickerson apparatus. On the organic side of the apparatus, *ca.* 12 mL of OmniSolv-grade dichloromethane (CH_2Cl_2) was poured into a 25-mL Kuderna-Danish concentrator tube (Kontes) containing an ebullator. The concentrator tube was connected to the Likens-Nickerson apparatus and a small heated water bath was placed underneath the tube to provide the necessary thermal energy so that the organic solvent could boil. A sufficient amount of CH_2Cl_2 was poured in the apparatus to fill the U-tube. The cooling water for the condensers and the heating/stirring mantle were turned on. Meat flavour volatiles were distilled/extracted for 3 hours; timing began once the first drop of aqueous condensate mixed with organic solvent in the U-tube. After distillation-extraction was complete, the glassware was permitted to cool and the organic phase was drained from the U-tube of the apparatus *via* a stopcock. The extract was then dried over 1-2 g of anhydrous granular sodium sulphate. The volume of the dried organic layer was reduced to 0.8-1 mL by attaching a bushing adapter and a three-chamber Snyder column to the Kuderna-Danish concentrator tube followed by heating in a 50°C waterbath. After concentrating the sample, the extract was transferred by Pasteur pipette into a 2-mL GC vial, capped, crimped and stored at -18°C until analysed by GC and GC-MS.

GC and GC-MS Analyses: An Agilent Technologies 6890 gas chromatograph (Agilent Technologies, Wilmington, DE) equipped with a capillary split/splitless inlet with electronic

pressure control, a 7683 ALS autoinjector module, a 7683 automatic liquid sampler tray module, a flame ionization detector (FID) and GC ChemStation software was used for profiling of meat flavour volatiles from specialty livestock. Operating conditions included the following: the column was a J&W fused-silica DB-5 capillary column (0.25 mm *i.d.*, 60 m x 0.25 μm); ultra-high purity helium was the carrier gas at a flow rate of 1.8 mL/min; the inlet was set at 250°C for splitless injection with a head pressure of 28.42 psi and a sample injection volume of 1.0 μL; the FID detector was set at 300°C with a hydrogen flow of 40 mL/min, air flow of 450 mL/min and makeup helium flow of 45 mL/min; the oven was set at 35°C and held there for 2 min before ramping at 5°C/min up to 280°C and then holding the temperature for an additional 4 min (the total run time was 55 min); analyses were performed in constant flow mode so that pressure changes were corrected by the electronic pressure controller in the 6890. The compounds separated were tentatively identified by retention time matching with authentic standards, comparison to Kováts indices and by GC-MS analysis.

Although GC is a means in which to separate the hundreds of compounds within a mixture, gas chromatography-mass spectrometry (GC-MS) was necessary to assist in identification of the chemical nature of the flavour volatiles. A Fisons 8060 gas chromatograph (Fisons Instruments, Inc., Beverly, MA) equipped with a J&W fused-silica DB-5ms capillary column (0.25 mm *i.d.*, 60 m x 0.25 μm) was used for GC-MS analyses. The GC oven temperature was set at 40°C and held there for 2 min before ramping at 5°C up to 280°C and then holding the temperature for an additional 4 min. Mass spectra were recorded by electron impact (EI) using a VG analytical mass spectrometer (Manchester, UK). The conditions for EI were as follows: ion source temperature, 200°C; ionisation energy, 70 eV; mass range, 28-500 amu; and pressure 1×10^{-7} bar. Compound identities were ranked according to purity and mixture matches from mass spectral data using the NIST and NISTREP libraries.

Results and Discussion:

A large portion of the time devoted to the characterization of flavour volatiles from meat of specialty livestock was directed toward method development. After much review through the literature, dichloromethane was selected as the organic solvent to collect/trap the meat flavour volatiles and three hours for distillation/extraction was chosen. Splitless injection was employed for the GC analysis, as was a slow temperature climb of the GC oven from 35°C to 280°C. Two or three internal standards were employed, these being 2-heptanone,

3-heptanone and *n*-tridecane.

The Likens-Nickerson simultaneous distillation-extraction apparatus was effective in collecting meat flavour volatiles of the mid- to high-molecular weight range (Fig. 3.1). Although any immiscible organic solvent could theoretically be used to collect the volatiles, dichloromethane was chosen because it is easier to work with than ether, and seems to be quite commonly employed as evident from the scientific literature. The operation of the Likens-Nickerson apparatus is basically quite simple: meat flavour volatiles are carried along with water vapour to the centre of the apparatus where they come in contact with a cold condenser. Heat transfer occurs and the vapours condense. Simultaneously from the adjacent side of the apparatus, organic vapours reach the condenser, condense and mix with the aqueous condensate. During this period, mass transfer occurs as meat flavour volatiles are transferred from the aqueous to the immiscible organic phase. Because the meat itself never comes in contact with the CH_2Cl_2, contamination of matrix constituents such as lipid constituents is avoided. Thus, a "clean" extract results. The heat/mass transfer operations continue until vapour no longer reaches the condenser. Thus, addition of internal standards to the meat slurry before distillation begins is necessary for quantitative purposes. According to the data obtained, low molecular weight volatiles such as hydrogen sulphide, formaldehye, ammonia, propanal and propanone were absent. Most likely they were either lost from the extract during the concentration step or eluted from the GC column at the same time as that of the solvent peak. To overcome these technical problems, a purge-and-trap apparatus hooked up to the injector of the GC or cryofocusing before injection would be required.

Volatiles were collected from meat of specialty species including bison, elk, deer, emu, wild boar, lamb and goat as well as those from domestic species including beef and pork. This study identified a number of aldehydes, ketones, alcohols, hydrocarbons, heterocyclics in the volatile extracts collected from specialty livestock. From a qualitative standpoint there was a striking resemblance between the aroma profiles of meats from specialty livestock, but quantitatively there were differences. A number of the chromatograms from these specialty meat species as well as pork and beef are provided at the end of this section. Aliphatic aldehydes and alcohols, some unsaturated analogs and only a very small amount of heterocyclic compounds dominated the aromagrams so obtained. This is not surprising because lipid degradation products are known to contribute to meat flavour and have low

odour threshold values (in the parts-per-billion range). Saturated and unsaturated aldehydes of six to ten carbon atoms have been reported to be major volatile components of all cooked meats. Sensorially, these aromas have been described as being "green," "fatty" and "tallowy." One of the main routes for the formation of meat volatiles during cooking is the thermally induced oxidation of the acyl chains of triacylglyerols and phospholipids; this process plays an important role in the generation of desirable meat flavours. The reactions by which volatile aroma compounds are formed from lipids follow the same general pathways for both thermal oxidation and autoxidation, although subtle changes in the mechanisms give rise to different profiles of volatiles in these two systems. The nature of the volatile product for a particular hydroperoxide depends upon the composition of the alkyl chain and the position where cleavage of the chain takes place. Further reaction of intermediate radicals provides a range of different volatile products, which contain unsaturated alkyl chains, and adds to the complexity of the mixture of volatiles. In this study, the dominant volatiles found in species such as elk, deer, emu, lamb and goat were 1-pentanol, hexanal, 2-furaldehyde, 1-octen-3-ol and 1-octanal. In pork and wild boar these volatiles were present in addition to marked amounts of 4-methyl-1-penten-3-ol, nonanal, *E*-2-nonenal, and *E,E*-2,4-decadienal. The latter three compounds, including hexanal, are typical secondary oxidation products of the omega-6 fatty acid, linoleic acid. Pork and boar are known to contain larger amounts of this unsaturated fatty acid than that of beef.

Throughout the period of this AFIF program, it became obvious that bison was of great importance. In terms of developing a sustainable industry for specialty meat and products there from, the bison industry seemed to be far ahead of any of the other emerging species. For this reason, particular attention was paid toward the flavour constituents of cooked bison. Presented in Table 3.1 is a list of volatile constituents from cooked bison meat, which had been stored under refrigeration conditions for two days, and a typical GC profile is depicted in Fig. 3.2. There were over 200 volatile constituents separated of which 114 were identified based on retention time matching of authentic standards, Kováts indices (KI) and mass spectral data. The Kováts retention index expresses the retention time of an unknown compound to that of normal paraffin standards (*i.e.*, octane has a KI of 800, nonane has a KI of 900, decane has a KI of 1000, etc.). Because Kováts indices are determined according to the capillary column and GC temperature program employed for unknown flavour volatiles, they can be useful in identifying monofunctional compounds of low molecular weight. Gas chromatography-mass spectrometry (GC-MS) was also used to identify the composition of

the volatile components from the specialty meats. After separation of volatiles by the GC, the mass spectrum was recorded for each unknown peak and the spectral pattern compared to similar ones in the NIST and NISTREP libraries of the computer system. The NIST and NISTREP libraries used in this study had compiled mass spectra for 62,235 and 12,593 compounds, respectively.

Of the compounds identified from cooked bison meat, there were 34 aldehydes, 23 alcohols, 21 ketones, 21 hydrocarbons & aromatics, and 15 heterocyclic, halogenated and miscellaneous compounds. A number of compounds, particularly in the latter stages of the GC chromatogram, could not be identified. This is because of a lack of matching mass spectra in the computer library system, as well as the fact that mass spectra become more complicated for molecules of larger molecular weight. With larger molecules more fragment patterns are generated; these result from the kinetic energy of the ion source and the particular instrument in question. Additionally, molecular ions of the compound ($M^{+\bullet}$) are not always present in a mass spectrum, and this makes it difficult to find appropriate matches from the computer library. For this reason, mass spectral libraries of authentic standards are often created for each spectrometer in question. At any rate, the larger mass volatiles eluting at later points in the GC chromatogram are most likely hydrocarbons and are not believed to significantly contribute toward meat flavour. It is the smaller molecular weight molecules that are most important.

This study identified only a few heterocyclic compounds: the most noticeable ones being 2-ethylfuran, 2-pentylfuran, allyl thiopropinoate and 2-acetylthiazole. There are three main reasons for a lack of heterocyclic compounds being detected in the aromagrams. The first being that the presence of carbonyl compounds from lipid oxidation interact with heterocyclic precursors such as hydrogen sulphide and ammonia and thereby limit the formation of heterocycles through the Maillard reaction. Hydrogen sulphide is a breakdown product of thiamine and *S*-containing amino acids such as cysteine, whereas ammonia comes from deamination reactions during the breakdown of amino acids, peptides, nucleotides and protein constituents. These small molecules are key precursors to *S*-containing heterocycles such as thiolanes, thiophenes and thiazoles as well as *N*-containing heterocycles such as pyrroles and pyrazines. Secondly, meat samples were cooked in a waterbath. By employing this method of cooking, the surface of the minced product does not become dry and experience the higher temperatures associated during roasting.

Although the Maillard reaction between reducing sugars and amino compounds does not require the very high temperatures associated with protein pyrolysis, it occurs much more readily at low moisture levels; hence in meat, flavour compounds produced by the Maillard reaction tend to be associated in the areas of the cooking meat which have been dehydrated by the heat source. When roasting bison meat more Maillard reaction products are formed than by the cooking method employed in this study, and these are the precursors to heterocycle formation. In fact, meat flavours with "roast" notes have been reported to be associated with heterocyclic compounds (e.g., pyrazines and thiazoles) formed in the latter stages of the Maillard reaction. Thirdly, the FID of a gas chromatogram is not very sensitive to heterocyclic compounds, particularly *S*-containing ones. Through the olfactory detector of the gas chromatograph, the presence of *S*-containing volatiles were noticed; however, only a small peak appeared on the GC chromatogram. Sulphur-containing compounds occur at low concentration in cooked meat, but their very low odour thresholds make them important contributors to the desirable aromas of cooked meat. These sulphur compounds have sulphurous, onion-like and meaty aroma notes and they probably contribute to the overall flavour by providing sulphurous notes, which form part of the aroma of "boiled meat." In order to find and identify more *S*-containing heterocycles, a detector other than a FID would be needed.

Although a large number of volatiles are present, it is believed that a relatively small number of compounds actually play an important role in the overall flavour of cooked meat. Of the compounds isolated from cooked meats of specialty livestock, the question becomes which volatiles contribute to the characteristic aroma of that particular species. This question is very difficult to answer, but aroma extract dilution analysis (AEDA) may help. Odour impact compounds depend both on their concentration and odour threshold; that is, how sensitive is the human nose to a particular compound. Researchers have reported that odorants such as *E*-2-undecenal, *E*-2-nonenal, *E,E*-2,4-nonadienal, *E,E*-2,4-decadienal, 2-furfurylthiol, hexanal, octanal, and acetaldehyde to be character impact compounds of freshly boiled red meats. Because different studies have reported different sets of compounds carrying the flavour of boiled meat, it appears that several sets of flavour chemicals are responsible for desirable meat aroma notes, and that no single combination of chemicals can claim responsibility for this sensory attribute. As most of the meat aroma-eliciting compounds listed above are lipid-derived aldehydes, the role of lipid oxidation products and warmed-over flavour, which can subsequently develop in these meats, is of importance. The

changes in the dominant volatiles from freshly cooked and stored bison meat are being compared with those of beef counterparts, and the data are being compiled in a manuscript, which will be sent to the *Journal of Agricultural and Food Chemistry* for consideration of publication.

People Involved:

- **R.B. Pegg**
- **P.K.J.P.D. Wanasundara**
- **U. Fernando**
- **C. Yu**

Table 3.1. Volatile Constituents Identified in Cooked Bison Meat Stored for 2 Days at 4°C.

Peak No.	Compound		Retention time (min)[a]	KI[a]	Identification method[b]
	Aldehydes				
1	2-methylpropanal (isobutyraldehyde)	5.278	641		std, gc-ms
4	butanal (butyraldehyde)		5.912	660	std, gc-ms
9	3-methylbutanal (isovaleraldehyde)		7.005	692	std, gc-ms
12	2-methylbutanal		7.267	701	gc-ms
17	pentanal (valeraldehyde)		7.752	715	std, gc-ms
35	hexanal		10.661	802	std, gc-ms
40	*E*-2-hexenal		12.271	850	std, gc-ms
49	heptanal		13.926	901	std, gc-ms
54	*E*-2-heptenal		15.713	953	std, gc-ms
57	benzaldehyde		16.142	965	std, gc-ms
67	octanal		17.243	998	std, gc-ms
69	*E,E*-2,4-heptadienal		17.515	1006	std, gc-ms
75	phenylacetaldehyde		18.638	1042	std, gc-ms
77	*E*-2-octenal		19.035	1055	std, gc-ms
87	nonanal		20.484	1101	std, gc-ms
91	*E,Z*-2,6-nonadienal		21.987	1150	std, gc-ms
92	*E*-2-nonenal		22.179	1157	std, gc-ms
93	4-ethyl-benzaldehyde		22.415	1164	gc-ms
96	*E*-undec-4-enal		23.203	1191	gc-ms
99	decanal		23.529	1201	std, gc-ms
100	*E,E*-2,4-nonadienal		23.800	1211	std, gc-ms
104	*E*-2-decenal		25.152	1259	std, gc-ms
112	undecanal		26.448	1305	gc-ms
114	*E,E*-2,4-decadienal		26.725	1315	std, gc-ms
118	*E*-2-undecenal		27.952	1361	std, gc-ms
128	dodecanal		29.110	1405	gc-ms
140	10-undecenal		31.283	1489	gc-ms
142	tridecanal		31.668	1505	gc-ms
153	tetradecanal		34.115	1610	gc-ms
158	pentadecanal		36.456	1715	gc-ms
162	hexadecanal		38.817	1826	gc-ms
168	13-tetradecenal		40.367	1902	gc-ms
176	octadecanal		42.935	2034	gc-ms
180	17-octadecenal		44.618	2128	gc-ms
	Alcohols				
5	2-butanol		6.123	666	std, gc-ms
7	2-methyl-1-propanol		6.346	673	std, gc-ms
8	1-butanol		6.868	688	std, gc-ms
14	4-methyl-1-penten-3-ol		7.392	704	std, gc-ms
23	3-methyl-1-butanol		8.795	746	gc-ms
24	2-methyl-1-butanol		8.863	748	gc-ms
29	1-pentanol		9.614	771	std, gc-ms
39	4-hydroxy-3-hexanone		12.125	846	gc-ms
45	1-hexanol		12.774	866	gc-ms
50	2-butoxyethanol		14.034	903	gc-ms
58	1-heptanol		16.296	970	std, gc-ms
59	1-octen-3-ol		16.504	976	gc-ms

61	7-octen-4-ol	16.713	982	gc-ms
66	2-methyl-5-(1-methylethenyl)cyclohexanol	17.136	995	gc-ms
68	4-ethylcyclohexanol	17.423	1003	gc-ms
71	2-ethyl-1-hexanol	18.075	1024	gc-ms
73	2,4-dimethylcyclohexanol	18.318	1032	gc-ms
79	*E*-2-octen-1-ol	19.326	1064	gc-ms
80	1-octanol	19.385	1066	gc-ms
85	2-methyl-3-octanol	20.208	1092	gc-ms
108	2-butyl-1-octanol	25.662	1277	gc-ms
137	14-methyl-(Z)-8-hexadecen-1-ol	30.946	1476	gc-ms
169	dihydrocycloheptadecanol	40.781	1923	gc-ms
	Ketones			
3	2,3-butanedione	5.879	659	std, gc-ms
5	2-butanone	5.980	662	std, gc-ms
10	1-hydroxy-2-propanone	7.054	694	gc-ms
16	2,3-pentanedione	7.710	714	std, gc-ms
19	3-hydroxy-2-butanone	8.147	727	gc-ms
32	2-hexanone	10.127	786	gc-ms
47	2-heptanone	13.694	893	std, gc-ms
56	3-ethylcyclopentanone	15.926	959	gc-ms
60	2,3-octanedione	16.597	979	std, gc-ms
62	2,6-dimethyl-3-heptanone	16.792	985	gc-ms
74	*E*-3-octen-2-one	18.399	1034	gc-ms
78	acetophenone	19.165	1059	std, gc-ms
84	2-nonanone	20.083	1088	gc-ms
86	6-methyl-3,5-heptadien-3-one	20.366	1097	gc-ms
89	3-nonen-2-one	21.541	1135	gc-ms
95	2-decanone	23.134	1188	gc-ms
103	cyclononanone	24.583	1239	gc-ms
130	3,10-dimethyl-(E)-5,9-undecadien-2-one	30.136	1445	gc-ms
133	4-pentylbenzaldehyde	30.605	1463	gc-ms
146	1,5-bis(1,1-dimethylethyl)-3,3-dimethyl-bicyclo[3.1.0]hexan-2-one	33.081	1565	gc-ms
148	4-(ethenylphenyl)-2-butanone	33.401	1579	gc-ms
	Hydrocarbons and Aromatics			
21	1-ethoxy-pentane	8.657	742	gc-ms
28	toluene	9.381	764	
33	2,4-dimethyl heptane	10.327	792	gc-ms
46	*p*-xylene	12.910	870	gc-ms
65	3-methyl-6-(1-methylethenyl)cyclohexane	17.067	993	gc-ms
73	3-ethyl-2-methyl-1,3-hexadiene	18.282	1031	gc-ms
76	1-ethyl-2-(4-methylpentyl)cyclopentane	18.856	1049	gc-ms
106	2,10-dimethylundecane	25.286	1263	gc-ms
107	2,9-dimethylundecane	25.393	1267	gc-ms
111	tridecane	26.327	1300	gc-ms
115	4-ethyl-3-nonen-5-yne	26.884	1321	std, gc-ms
116	1-methoxy-4-methyl-bicyclo[2.2.2]octane	27.428	1341	gc-ms
117	1,3*E*,5*Z*-undecatriene	27.876	1358	gc-ms
123	cyclodecane	28.653	1387	gc-ms
125	tetradecane	28.860	1400	std, gc-ms
132	2-methyltetradecane	30.453	1457	gc-ms
136	1,2,3,4-tetrhydro-2,5,8-trimethylnaphthalene	30.823	1471	gc-ms
141	pentadecane	31.376	1500	std, gc-ms
150	hexadecane	33.746	1594	std, gc-ms

157	heptadecane	36.002	1694	std, gc-ms
164	3,7,11,15-tetramethyl-2-hexadecene	39.376	1854	gc-ms
	Heterocycles, Halogenated, and Miscellaneous Compounds			
2	dichloroethane	5.390	644	gc-ms
15	allyl thiopropionate	7.543	709	gc-ms
18	2-ethylfuran	7.829	717	std, gc-ms
26	2,3-dihydro-4-methylfuran	9.099	755	gc-ms
27	methyl(methylthio)methyl disulphide	9.262	760	gc-ms
38	2-furaldehyde	11.612	831	std, gc-ms
52	3-methylthiopropanal	14.247	910	gc-ms
53	2-ethylphenol	14.709	923	gc-ms
64	2-pentylfuran	16.941	989	std, gc-ms
70	2-acetylthiazole	17.780	1015	gc-ms
101	benzothiazole	24.183	1225	gc-ms
102	5-[2-butyrylethyl]pyrrolidin-2-one	24.302	1229	gc-ms
110	2,2'-[oxybis(methylene)]bis-furan	26.097	1292	gc-ms
154	4,5-diphenyloxazole	34.854	1643	gc-ms
171	hexadecyloxirane	41.902	1979	gc-ms

[a]Retention times and Kováts indices (KI) were determined using a 5% phenyl-methylpolysiloxane fused-silica capillary column.
[b]Identification method: authentic standard, std; gas chromatography-mass spectrometry, gc-m

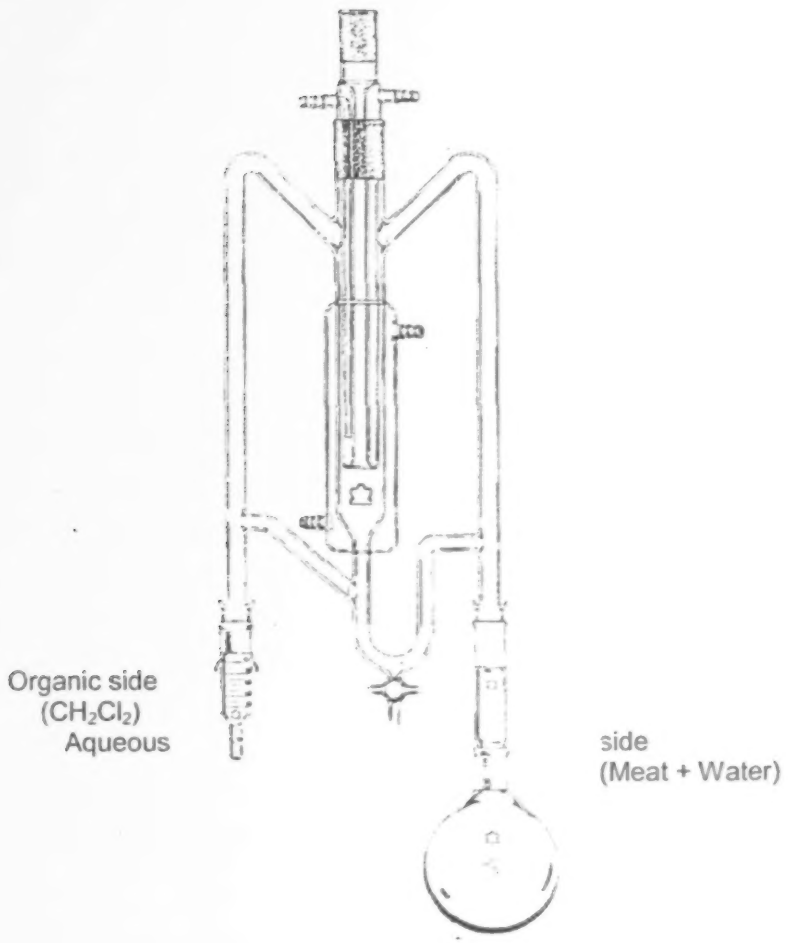
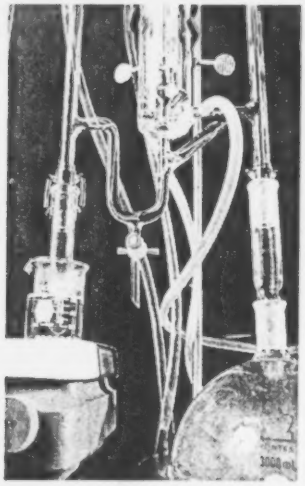
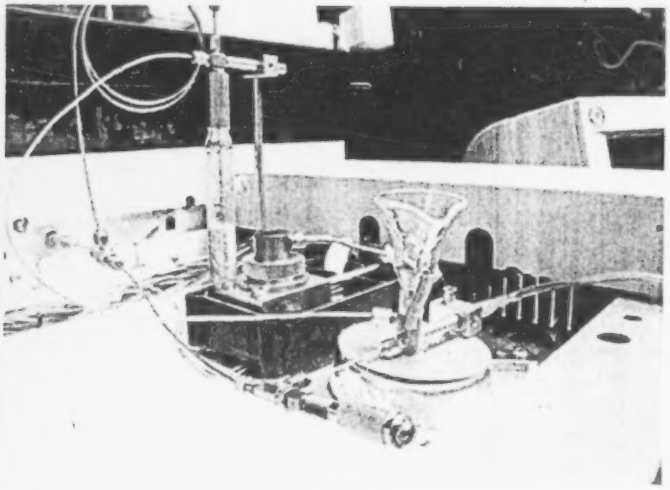


Figure 3.1. Likens-Nickerson Simultaneous Distillation-Extraction Apparatus (Adapted from the Kimble/Kontes Complete Laboratory Glassware Catalog)





OBJECTIVE 3

To investigate the flavour of meat from specialty livestock as a means to better understand its makeup so that possible strategies can be developed in order to control/limit the impact of undesirable flavour-active compounds in processed meat products.

Activity 4.1: A Guide to Export and Labelling Regulations for Specialty Livestock Meat and Meat Products

The specialty livestock meat industry faces many challenges, most importantly inherent palatability issues and proper marketing of meat and meat products. Due to a lack of organized industry structure, producers are facing an uphill battle to make specialty livestock farming a profitable venture. Unavailability of reference materials from relevant studies has also been a problem. The Saskatchewan Specialty Livestock Value-Added Program has dedicated its resources and expertise to address these issues. Apart from its main objective of designing processes to improve palatability of specialty meats, the program has tried to address some of the basic questions regarding domestic and foreign trade of specialty meats. This effort involved a comprehensive literature search and personal communication with relevant organizations and individuals involved in regulations of meat trade. The information thus collected was collated into a workable package. This easy-to-use, quick reference guide is not only relevant to specialty meats (*i.e.*, from bison, deer, elk, wild boar, goat, ostrich, emu and other ratites), but also offers regulatory information pertaining to meats from domestic species (*e.g.*, beef, pork, mutton). This document is a handy reference guide for individuals or organizations involved in the meat trade. The guide includes the following:

- Information on organizations/agencies involved in the meat trade.
- Export, import and labelling guidelines for the USA, EU, Australia, New Zealand and selected Asian markets (*i.e.*, China, Japan, Hong Kong, Korea, Taiwan).

Furthermore,

- All information is supplemented with a summary of relevant contacts and website addresses for quick access.
- The document is spiral bound with thick glossy pages for easy reference.

We believe that this guide will be a valuable tool for every meat producer and processor.

A copy of the guide is included with this report. We acknowledge the contributions of D. Prefontaine and S. Lui from the Saskatchewan Food Industry Development Centre on this activity.

People Involved:

- **J.S. Dhanda**
- **D.J. Schenher**
- **S.Y.C. Lui**
- **R.B. Pegg**
- **P.J. Shand**
- **D.J. Prefontaine**

a guide to EXPORT AND LABELLING REGULATIONS FOR

Specialty Livestock Meat and Meat Products

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Canada Saskatchewan

FOOD PRODUCT Innovation PROGRAM

OBJECTIVE 4

To compile a summary of current regulations required for emerging species (*i.e.*, value-added meat products) to adhere to export standards for shipment to North America.

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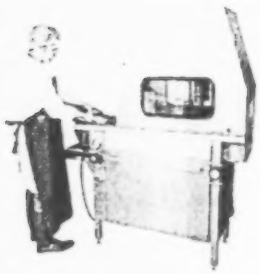

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Activity 5.1:	Product and Process Development / Technology Transfer

Background and Objectives:

The specialty livestock industry has been growing in Saskatchewan, although some health and marketing issues have hindered the growth of some species. There has been a steady demand for the development of value-added products and processing techniques to accommodate the specialty livestock meat sector. Currently, most product development initiative involve utilizing lesser value cuts of meat and the trimmings with an aim to increase the overall value of the carcass. Lesser value cuts have been used to produce whole muscle products, while trimmings are being utilized in the production of restructured and comminuted meat products. A large focus of development has been in the snack food market; examples include jerky, pepperoni and beer sausage. Other deli products and specialty items such as salamis, smoked sausage and garlic sausage have also seen an increased interest. Determining the shelf life of fresh retail cuts during transportation and ready-to-eat products for the hotel restaurant institution (HRI) trade is also being explored. With this concept in mind, the possibility of home meal replacement (HMR) at a retail level (specialty shops and supermarkets) is at hand.

The focus of the SLVAP was to conduct research and to provide a platform for the development of the specialty livestock meat industry, and in turn to increase viable overall growth of this industry in Saskatchewan. During the last 3 years the program utilized resources, equipment and expertise from the SFPIP for its activities, especially for the development of new meat products and processes. Contributions of D.D. Pobereznek, W.P. Rogers and R.T. Sefton (all personnel from SFPIP) are gratefully acknowledged. After identifying or developing various technologies, the task is to disseminate this information to the industry *via* seminars, meetings, workshops, newsletters and other innovative means. The program has also been in close contact with other programs related to specialty livestock such as the Specialized Livestock Marketing Research Group (Department of Agricultural Economics), the Specialized Livestock Research Program (Western College of Veterinary Medicine) and Saskatchewan Agriculture,

Food and Rural Revitalization personnel. These associations helped the program in deciding the direction and selection of its research projects.

Detailed Description:

Over the past three years several product development projects were undertaken with producers, processors, associations and cooperatives. All these projects were aimed for the domestic market, and where applicable, some for export markets. To name a few, Songlines Emu – jerky (health benefits), Canadian Classic Wild Boar (fatty acid analysis for health benefits), North American Bison Association – Canadian label preparation, Ogilvie Ostrich Farms – jerky, Manitou Springs Bison Ranch – bison pemmican, Saskatoon Specialty Meats – wild boar hams as well as several other small and medium-sized projects. One of the major product development projects undertaken by the program was in collaboration with the Saskatchewan Bison Association, Specialized Livestock Marketing Research Group (Department of Agricultural Economics) and Saskatchewan Food Industry Development Centre, in an AFIF-funded project. This project analyzed the consumer demand for bison meat products in key Canadian markets, focusing on the lesser value bison cuts. The project was aimed to better understand consumer preferences for bison, the preferred characteristics of bison meat products and the "willingness-to-pay" for these products by consumers.

Many ranchers are seeing their herds reach a point where they need to cull some animals. They are looking for ways to produce acceptable products rather than grind the entire animal into "hamburger." Many specialty livestock producers have an aversion to incorporating marinates and non-meat ingredients into their meat products. They say that it removes the "natural" image that their products have. Nevertheless one of the limiting factors in acceptance of specialty products is that they tend to be very lean and are often over cooked. Resultant products are dry and give the consumer an unpleasant eating experience. This can be easily overcome through the inclusion of marinades or non-meat ingredients at levels sufficient to compensate for most of the cooking losses, resulting in a more succulent and satisfying eating experience without losing the characteristic flavour of the meat in question. Projects have become more diverse. Several clients came in with only a vague idea of what they wanted. We have been able to help develop their concept and to prepare product prototypes. Several products are currently being processed in cooperation with the Saskatchewan Food Industry Development Centre. Other producers

are in the process of developing a marketing plan and the logistics of sales and distribution. Other projects included technical assistance and product development in marination of low value trims and cuts.

During the past three years, technical questions were addressed on a regular basis. Generally these questions pertained to processing procedures and techniques. Textural problems seem to be the common hurdle, particularly in restructured products, as meat from specialty livestock species is generally lean and tends to be drier and crumblier when restructured. Other issues related to quality assurance/control (*e.g.*, how to maintain high quality and provide a safe and wholesome product to the consumer?) Questions such as these were handled on one-to-one basis over the phone, through e-mails and by direct communication during various trade shows attended by SLVAP personnel. In our first fact sheet, the issues related to tenderness of bison top rounds were presented (Appendix 4). This document has been posted on our web site (www.ag.usask.ca/sfpip) and also by the Bison Centre of Excellence on its web page (www.bisoncentre.com).

Furthermore, many technical assistance projects in the form of consulting/troubleshooting and extension were undertaken, in addition to the product development initiatives. As already mentioned, the main thrust of the program was to conduct meat research and to assist in the development of a sustainable specialty livestock meat industry. For this reason many hours have been devoted to research and outreach activities. As consumer awareness and demand for leaner meat products increase and specialty livestock herd sizes become larger, we expect to see in the future a marked rise in product development assistance to the industry.

To publicize the program and to reach as many producer/processor groups, industry and government personnel as possible, the SLVAP, in conjunction with the SFPIP, updated its mailing/contact list (~1200 individuals), initiated a web site, developed a new look brochure and distributed its yearly newsletters. The SLVAP's meat scientist was a member of the Specialty Livestock Opportunity Area Team (funded by Agri-Food Equity Fund). The aim of this team was to identify research and development needs for the industry in the province. Members include people working in the specialized livestock sector from the University and

various governmental agencies. Close association with other specialty livestock projects funded by AFIF (*e.g.,* Specialized Livestock Marketing Research Group) associated the program in getting feedback from the industry and producer organizations. The program has been in communication with the Bison Centre of Excellence, located in Alberta, and a research database on bison at the Colorado State University, Fort Collins, CO. Personnel from the program attended a number of trade shows/conferences/meetings etc. during the past three years. These included Saskatchewan Elk Breeders' Annual Conventions, Meat Goat Production Seminar, International Bison Conference, Annual Conventions of Saskatchewan Meat Processors' Association, Saskatchewan Whitetail and Mule Deer Producers' Association Annual Conventions, Saskatchewan Bison Association Annual Field Days, Grand Opening of the Saskatchewan Food Industry Development Centre, International Animal Agriculture and Food Science Conference and International Congress of Meat Science and Technology. Important new contacts were made during these meetings.

People involved:

- **W.P. Rogers**
- **R.T. Sefton**
- **D.D. Pobereznek**
- **J.S. Dhanda**
- **R.B. Pegg**
- **P.J. Shand**
- **H.D. Silcox**

Activity 5.2:	Bison Product Development – an Enticing Project

Background and Objectives

There has been a steady demand for the development of value-added products and processing techniques to accommodate the specialty livestock meat sector. Most product development work has been to utilize lesser value cuts of meat and the trim, with an aim to increase the overall value of the carcass. The results from the marination studies on bison meat were very encouraging, so it was decided to take this technology a step further and use it for the development of actual products. In the year 2001, the SLVAP hired a chef to work with the program's meat scientist and product development specialist from the SFPIP. The idea was to "marry" some of the chef's skills with those of the meat scientist and product development specialist to produce some enticing value-added bison meat products.

Detailed Description

As aforementioned, it was planned to use lesser value cuts of meat for this activity: we used bison top round. The top rounds were injected with brine containing sodium chloride and sodium tripolyphosphate to achieve 10% extension by weight. Re-injection with a hand held injector compensated for any deviation from the target weight. The brine solution was formulated to achieve 0.5% sodium chloride and 0.2% sodium tripolyphosphate levels in the finished marinated product.

After marination, the chef developed recipes to suit the bison meat. He was quite impressed with the texture and tenderness of the injected bison top round. For this part of the activity, several recipes were tried over a period of 5 weeks. All recipes were well liked by the SFPIP staff and pictures of some of these mouth-watering dishes were taken and are included in this document (Plates 5.2.1-5.2.8). We showcased one of the products (bison kebobs) at the Annual Field Day of the Saskatchewan Bison Association (July 20-22, 2001) and it was very well received by the attendees. Efforts will be made to obtain some extra funding to try and finalize these recipes and collate them into a consumer-friendly guide.

People involved:

- J.S. Dhanda
- P. Phillips
- W.P. Rogers
- R.B. Pegg
- P.J. Shand
- R. T. Sefton

Plate 5.2.1. Bison Stew

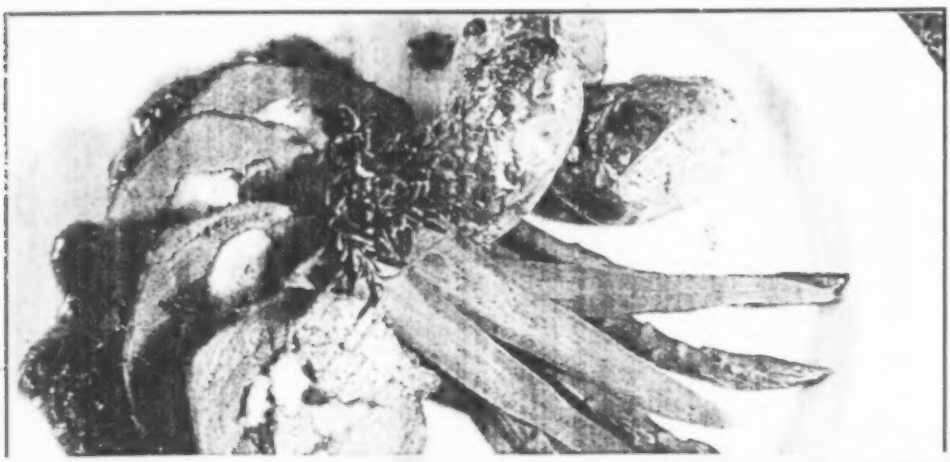


Plate 5.2.2. Bison Roll with Fruits and Bread Stuffing

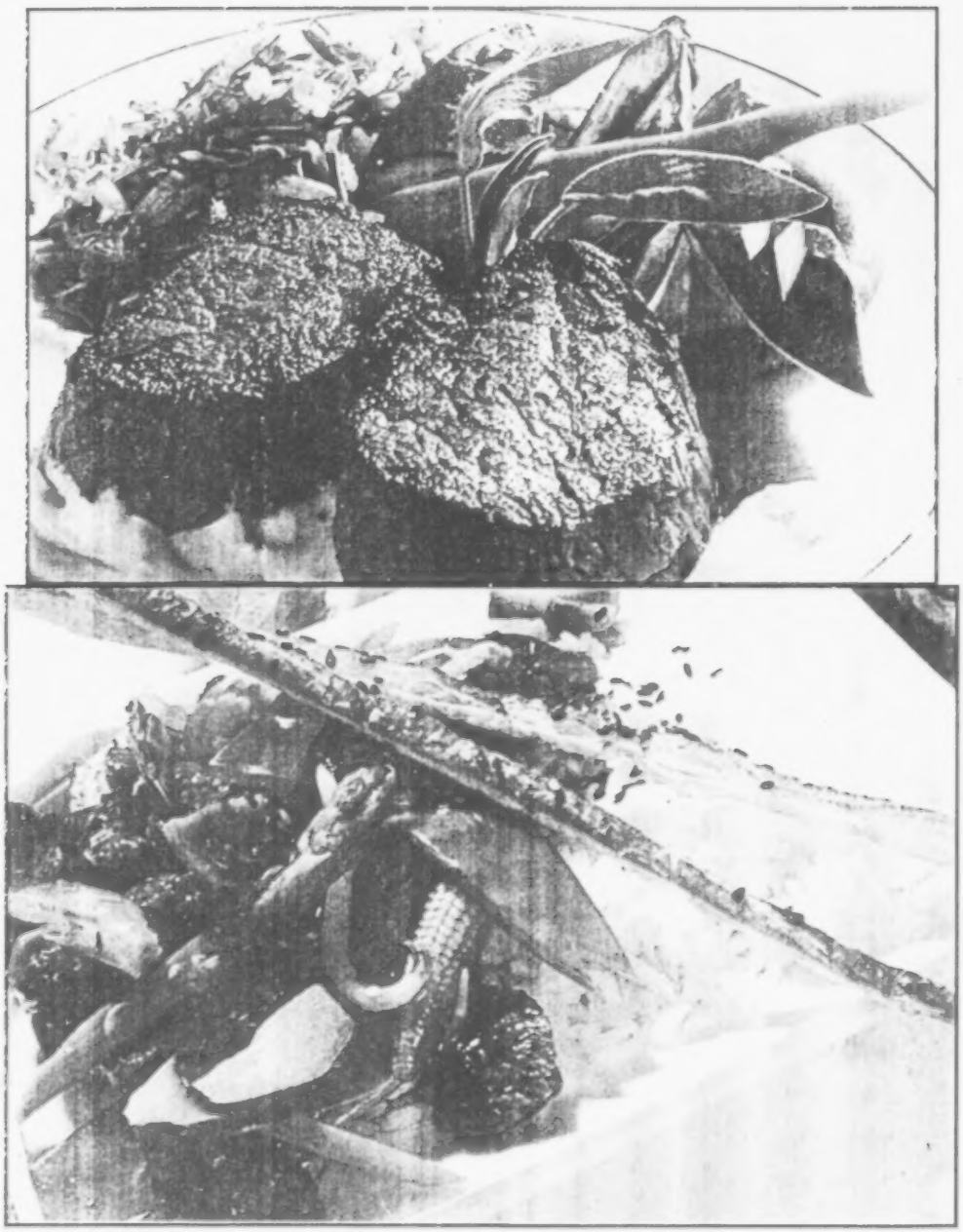


Plate 5.2.4. Bison Stir fry with Teriyaki Sauce

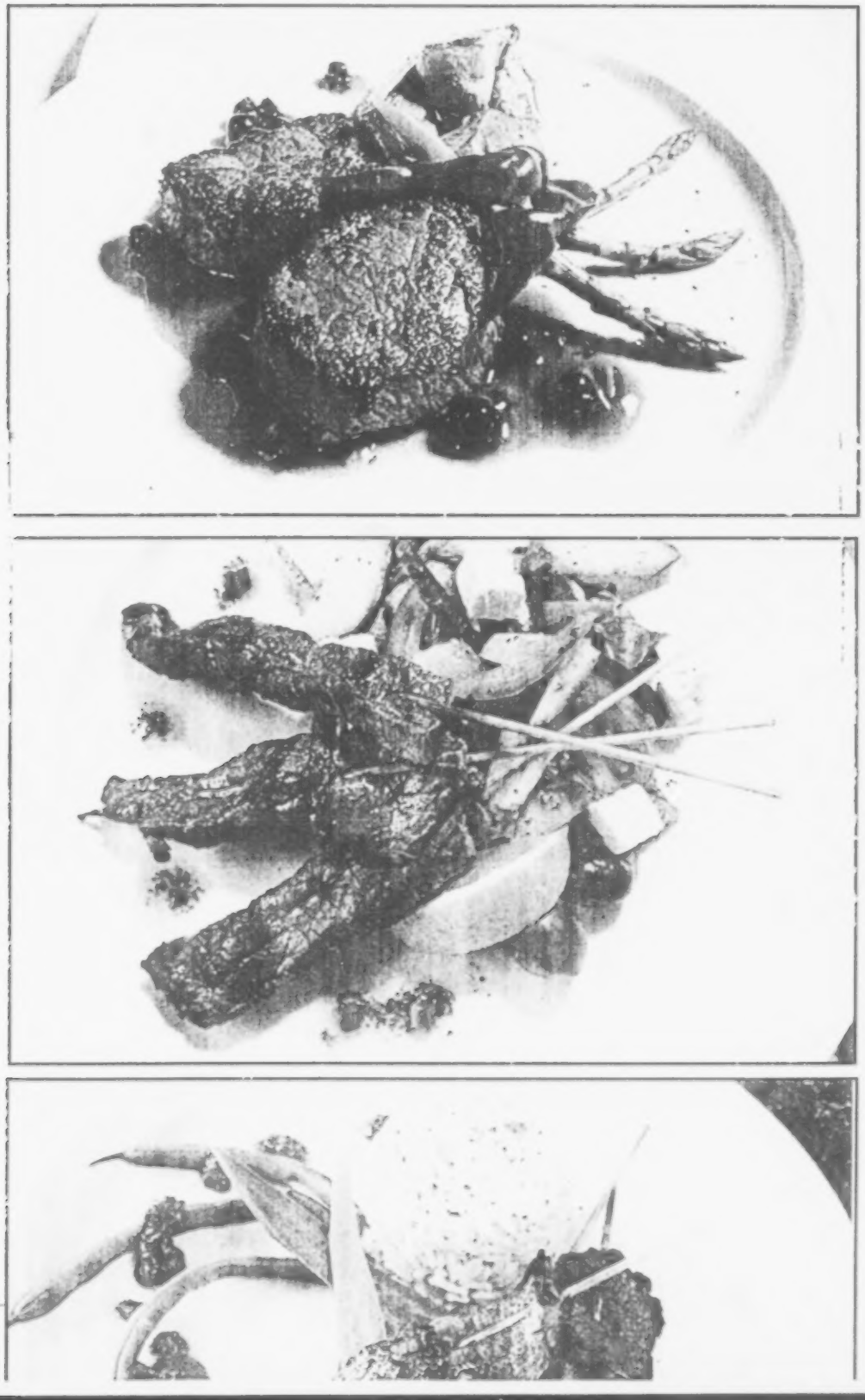
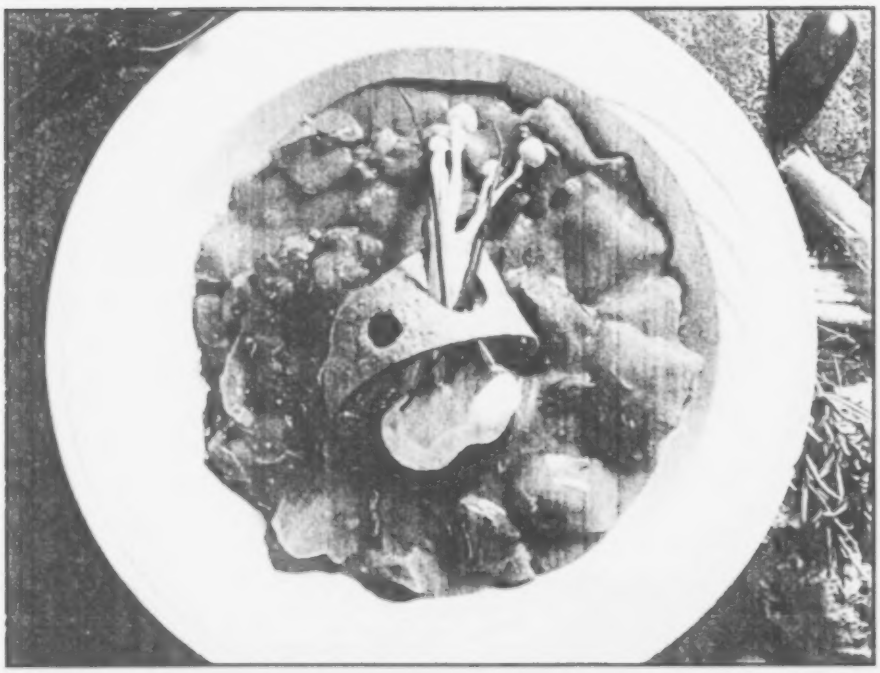


Plate 5.2.7. Bison Souvlaki with Lemon Rice



APPENDIX 1

Tours, Presentations, Meetings, Workshops and Media Contacts

Tours, Presentations, Meetings, Workshops and Media Contacts		Attendance
Jan 19, 2000	Enso Meat Goat Farm, Tour of the pilot plant facilities, D.D. Pobereznek.	2
Mar. 30-Apr. 1, 2000	Saskatchewan Elk Breeders' Association 2000 Annual Convention, Table Top Display highlighting the SLVAP and SFPIP, attendance J.S. Dhanda, R.B. Pegg, D.D. Pobereznek, J. Wanasundara and H. Silcox.	200
Apr. 4, 2000	Meeting with Dr. Gordon Greer, Head (Meat Science Group), Agriculture and Agri-Food Canada Research Centre, Lacombe, AB, regarding the possibility of a collaborative research project on bison meat, attendance, J.S. Dhanda.	2
Apr. 7, 2000	Dr. Frank Pinkerton of Grapeland, TX and members of Meat Goat Association, Tour of pilot plant facilities, D.D. Pobereznek.	5
Apr. 8-9, 2000	Meat Goat Production Workshop, Demonstration in the AMFS Pilot Plant, Instruction and attendance, D.D. Pobereznek and J.S. Dhanda.	30
Apr. 13, 2000	Meeting with Specialty Livestock Marketing Group, University of Saskatchewan, attendance, J.S. Dhanda, R.B. Pegg and P.J. Shand.	5
May 10, 2000	Western Producer, Interview, J.S. Dhanda.	2

June 6, 2000	Bison processing and tour of Drake Meat Processors, Drake, SK, Attendance, D.D. Pobereznek and J.S. Dhanda.	15
June 12, 2000	Western Producer photo shoot and interview for the SLVAP, J.S. Dhanda and D.D. Pobereznek.	3
June 15, 2000	Teleconference, Specialty Livestock Research Groups at University of Saskatchewan (AFIF funded projects) and SAF, attendance, J.S. Dhanda.	6
June 22, 2000	Specialty Livestock Opportunity Area Meeting in Regina, SK, J.S. Dhanda and D.D. Pobereznek.	15
June 23-25, 2000	Saskatchewan Bison Association Field Day in Weyburn, SK, J.S. Dhanda (gave presentation) and D.D. Pobereznek.	250
June 29, 2000	Article on the SLVAP appeared in the "Diversified Livestock Producer" - a supplement to the Western Producer.	
July 13, 2000	News article on J.S. Dhanda's presentation at the Saskatchewan Bison Association Field Day in Weyburn, SK, appeared in the Western Producer.	

Aug. 1-4, 2000	International Bison Conference 2000, Edmonton, AB, attendance, J.S. Dhanda (gave presentation at a satellite research meeting) and D.D. Pobereznek.	1300
Nov. 7-8, 2000	AFIF Conference in Regina, attendance J.S. Dhanda and R.B. Pegg (also gave presentation).	~200
Nov. 16, 2000	SFPIP Steering Committee Meeting, attendance R.B. Pegg, P.J. Shand and J.S. Dhanda (gave presentation).	12
Nov. 28, 2000	Mitchell's Gourmet Foods - plant visit, attendance, D.D. Pobereznek, J.S. Dhanda and AMFS undergraduate Food Science students.	20
Dec. 5, 2000	Saskatchewan Katahdin Sheep Association Meeting, Food Industry Development Centre, Saskatoon, attendance, J.S. Dhanda, R.B. Pegg and D.D. Pobereznek.	15
Dec. 14, 2000	SAF personnel and people from the community, tour of the pilot plant and research facilities, J.S. Dhanda.	20
Dec. 15, 2000	Distribution of first SLVAP Newsletter (J.S. Dhanda, editor) and new SLVAP brochure.	~1200

Dec. 19, 2000	Teleconference, Specialty Livestock Opportunity Area Meeting in Saskatoon/Regina, SK, J.S.Dhanda and D.D. Pobereznek.	15
Jan. 2001	News article on the SLVAP published in the winter issue of the Forum Magazine, official publication of the Saskatchewan Meat Processors' Association.	
Feb. 14, 2001	Advisory committee meeting of Specialized Livestock Marketing Group at the Saskatchewan Food Industry Development Centre, Saskatoon, attendance, J.S. Dhanda.	22
March 2-4, 2001	Saskatchewan Meat Processors' Association Annual Convention. Table top display highlighting the SLVAP and SFPIP, attendance, P.J. Shand, R.B. Pegg, P. Rogers, J.S. Dhanda, J. Wanasundara, G. Dykes, Z. Pietrasik and H. Silcox.	~250
March 11, 2001	Meeting of personnel working with AFIF-funded projects related to specialized livestock, Saskatoon, attendance, J.S. Dhanda.	6
March 23-24, 2001	Annual Convention of Saskatchewan Whitetail and Mule Deer Producers' Association. Table Top Display highlighting the SLVAP and SFPIP, attendance, J.S. Dhanda and H. Silcox.	~300
March 28, 2001	Prof. Bruce Young, Animal Studies, University of Queensland, Australia, tour of the plant and research facilities, J.S. Dhanda.	1
March 29, 2001	Specialty Livestock Opportunity Area Meeting, Saskatoon, attendance, J.S. Dhanda.	15
March 29, 2001	Agriculture and Agri-Food Canada personnel, tour of the facilities and SLVAP research programs, J.S. Dhanda, R.B. Pegg and P.J. Shand.	3

April 11, 2001	Teleconference, Specialty Livestock Opportunity Area Meeting in Saskatoon/Regina, SK, J.S.Dhanda and D.D. Pobereznek.	15
April 12. 2001	Meeting with Peter Phillips, Chef/Owner of Bison Food Services regarding development of bison meat products, attendance, R.B. Pegg, J.S. Dhanda and W.P. Rogers.	4
April 12, 2001	Meeting with bison producers/owners of Buffalo Meat Co., Prince Albert regarding bison processing issues and role of SLVAP.	6
April 19-20, 2001	***Research meeting of the Western Group on Meat Safety and Preservation, Saskatoon, attendance, P.J. Shand, G. Dykes, W.P. Rogers, Z. Pietrasik and J.S. Dhanda.***	~20
May 15, 2001	Advisory committee meeting of Value-Added Beef Program, attendance. P.J. Shand, Z. Pietrasik, W.P. Rogers and J.S. Dhanda.	15
May16, 2001	Meeting with Peter Phillips, Chef/Owner of Bison Food Services, finalizing details of the project on the development of bison meat products, attendance, R.B. Pegg, J.S. Dhanda and W.P. Rogers.	4
May 29, 2001	Meeting with Dr. Marshall Patterson, Industry Specialist with Saskatchewan Bison Association, on bison product development and research issues, attendance, R.B. Pegg, W.P. Rogers and J.S. Dhanda.	4
June 2001	News article on SLAVAP appeared in the official newsletter (Vol. 38 No. 2) of the American Meat Science Association.	
June 13-14, 2001	Specialty Livestock Opportunity Area Team Meeting, Regina, SK, attendance, J.S. Dhanda.	16
July 20-22, 2001	Annual Field Day, Saskatchewan Bison Association, Saskatoon, SK, attendance, J.S. Dhanda, R.B. Pegg, P. Phillips, W.P. Rogers and J. Kamil.	~250

July 24-28, 2001	International Animal Agriculture and Food Science Conference, Indianapolis, IN, USA, attendance, Z. Pietrasik and J.S. Dhanda (gave presentation entitled "Effects of marination on the processing parameters and palatability of bison top round").	~4000
Aug. 11, 2001	Annual Field Day, Saskatchewan Whitetail and Mule Deer Producers' Association, Blue Mountain Resort, SK, attendance, W.P. Rogers (gave presentation).	~65
Aug. 16, 2001	Bison carcass cutting project and tour of the facilities at the Saskatchewan Food Industry Development Centre, attendance, J.S. Dhanda and W.P. Rogers.	8
Aug. 23, 2001	Saskatchewan Bison Association Bison Marketing Project meeting, Saskatoon, SK, attendance, J.S. Dhanda, W.P. Rogers and P.J. Shand.	8
Sept. 18, 2001	Grand opening of the Saskatchewan Food Industry Development Centre. Table top display highlighting the SLVAP and SFPIP, attendance, P.J. Shand, J.S. Dhanda, J. Wanasundara, G. Dykes, Z. Pietrasik.	~100
Sept. 19, 2001	A news article on SLVAP submitted to the editor of "TRACKING" - an official magazine of the Saskatchewan Whitetail and Mule Deer Producers Association.	
Oct. 19, 2001	Meeting of the Canadian Cervid Council, Saskatchewan Food Industry Development Centre, Saskatoon, SK, attendance, J.S. Dhanda.	12
Oct. 2001	News article on SLVAP published in the October/November 2001 issue of "TRACKING" - an official magazine of the Saskatchewan Whitetail and Mule Deer Producers' Association.	
Nov. 5, 2001	Saskatchewan Bison Association, Bison marketing project meeting.	6

	Saskatoon, SK, attendance, J.S. Dhanda, W.P. Rogers and P.J. Shand.	
Nov. 20, 2001	Request received from the Editor of "THE TRACKER" magazine for an article on the program and its involvement with bison, deer and elk industries.	2
Nov. 27, 2001	E-mail from the Communication Manager, North American Elk Breeders Association, MO, USA, regarding product development research conducting by the program on elk meat.	2
Dec. 4, 2001	Fact sheet on bison marination research was distributed along with the SFPIP newsletter to government personnel, industry and producer groups.	1200
Dec. 11, 2001	Request from Bison Centre of Excelience, Leduc, AB for posting the fact on bison marination on their website, which was accepted.	
Dec. 2001	An article on objectives and current research updates of the program was publishes in the Dec. 2001 issue of "THE TRACKER" magazine focusing on the bison, deer and elk industries.	
Oct.-Dec., 2001	Examined a Ph.D. thesis entitled "Evaluation of growth, body composition and meat quality of goats from various genotypes born in different months to produce Capretto, entire chevon and castrated chevon carcasses", University of Queensland, Australia.	
Jan. 15, 2002	Saskatchewan Bison Association, Bison marketing project meeting, Saskatoon, SK, attendance, J.S. Dhanda, W.P. Rogers and P.J. Shand.	6
Feb. 6-8, 2002	The 82nd Annual Conference of Canadian Meat Council, Ottawa, ON. Attendance, J.S. Dhanda and G.A. Dykes (both presented research papers).	~300
Feb. 15-17,	Saskatchewan Meat Processors' Association Annual Convention.	~250

2002	Table top display highlighting the SLVAP and SFPIP, attendance, P.J. Shand, R.B. Pegg, W.P. Rogers, J.S. Dhanda, J. Wanasundara, G. Dykes, Z. Pietrasik and H. Silcox.	
Feb. 20, 2002	Meeting with Native Bison Association of Saskatchewan regarding product development, attendance, P.J. Shand, W.P. Rogers, J.S. Dhanda.	6
March 7-9, 2002	Annual Convention of Saskatchewan Elk Breeders Association. Table top display highlighting the SLVAP and SFPIP, attendance, R.B. Pegg, W.P. Rogers and J.S. Dhanda.	~250
March 20-21, 2002	SAF Saskatchewan Rural Opportunities Conference. Table top display highlighting the SLVAP and SFPIP, attendance, P.J. Shand (gave presentation), W.P. Rogers and J.S. Dhanda.	~500
April 26, 2002	Lecture delivered on Meat colour at Short Course on Sausage and Meat Processing, University of Saskatchewan, April 26-28 (J.S. Dhanda).	~25
May 13-15, 2002	Attended a short course on SPSS for windows (J.S. Dhanda).	~40
May 22, 2002	Meeting regarding preparation of a manual on export and import regulations of specialty meat and meat products.	5
June 4, 2002	Request from the editor of Times Food Processing Journal for writing a review on goat meat production and processing.	
June 11, 2002	Follow up meeting on preparation of a manual on export and import regulations of specialty meat and meat products.	4
June 17, 2002	Saskatchewan Bison Association, Bison marketing project meeting. Saskatoon, SK, attendance, J.S. Dhanda, W.P. Rogers and P.J. Shand.	6
June 27, 2002	Review article entitled "Goat meat – A potential red meat alternative" accepted for publication in the July issue of Times Food Processing Journal.	
July 12-14, 2002	Annual Field Day, Saskatchewan Bison Association, Saskatoon, SK, attendance, J.S. Dhanda and W.P. Rogers.	~250
July 24,2002	Follow up meeting on preparation of a manual on export and import regulations of specialty meat and meat products.	5
July 28-31, 2002	The 55th Annual Reciprocal Meat Conference, Michigan State University. Attendance, P.J. Shand and Z. Pietrasik (both presented research papers).	~250
Aug. 1, 2002	Follow up meeting on preparation of a manual on export and	

	import regulations of specialty meat and meat products.	
Aug. 15, 2002	Follow up meeting on preparation of a manual on export and import regulations of specialty meat and meat products.	5
Aug. 25-30, 2002	48th International Congress of Meat Science and Technology, Rome, Italy. Attendance, P.J. Shand and J.S. Dhanda (both presented research papers).	4
Sept. 24, 2002	Review article entitled "Goat meat – A potential red meat alternative" authored by J.S. Dhanda, R.B. Pegg and P.J. Shand appeared in the July issue of Times Food Processing Journal.	
Oct. 10, 2003	Meeting regarding progress of SBA's bison marketing project, University of Saskatchewan, Saskatoon. Attendance, W.P. Rogers, R. Sefton and J.S. Dhanda.	12
Nov. 22, 2002	E-mail request from Registrar, Canadian Boer Goat Association regarding published information on goat meat that was mailed to the association.	
Dec. 5, 2002	E-mail request from a Ph.D. student from Chile regarding published information on goat meat that was mailed.	
Dec. 6, 2002	E-mail request from the editor of Deer Tracking – a magazine of the Saskatchewan Whitetail and Mule Deer Producers' Association for an article that was submitted.	
Jan 2003	A guide to Export and Labelling Regulations for Specialty	

	Livestock Meat and Meat Products authored by J.S. Dhanda, D.J. Schenher, S.Y.C. Lui, R.B. Pegg, P.J. Shand and D.J. Prefontaine was released.	
Feb. 5, 2003	E-mail request from Epidemiologist, Health Canada regarding published information on goat meat, which was mailed.	
Feb. 5-7, 2003	The 83rd Annual Conference of Canadian Meat Council, Quebec City. Attendance, P.J. Shand (presented research papers).	~250
Feb. 28 – March 2, 2003	Saskatchewan Meat Processors' Association Annual Convention. Table top display highlighting the SLVAP and SFPIP, attendance, P.J. Shand, R.B. Pegg, W.P. Rogers, J.S. Dhanda, J. Wanasundara, R. Sefton, Z. Pietrasik and H. Silcox.	~250
March 6-8, 2003	Annual Convention of Saskatchewan Elk Breeders Asscciation, Saskatoon. W.P. Rogers and J.S. Dhanda (gave presentation).	~250
March 28-30, 2003	Annual Convention of Saskatchewan Whitetail and Mule Deer Producers' Association, Saskatoon. W.P. Rogers and J.S. Dhanda (gave presentation).	~250

APPENDIX 2
PERSONNEL ASSOCIATED WITH SLVAP

PERSONNEL FUNDED BY THIS PROJECT
(for the period January 1, 2000 to December 31, 2002)

Dr. Jag Dhanda	Meat Scientist/Project Leader	12 person months (10 person months in the year 2000)
Mr. Paul Rogers	Product Development Specialist	1.5 person months
Mr. Jeff Lerouge	Graduate student	4 person months in the year 2000
Mr. Peter Phillips	Chef/Owner, Bison Food Services	Casual in the year 2001
Ms. Deana Schenher	Summer student	4 person months in the year 2002

Other Personnel Contributed to the Program from the University of Saskatchewan: (listed in alphabetical order)

Department of Applied Microbiology and Food Science

Dr. Gary Dykes
Mr. Michal Dworaczek
Ms. Ursla Fernando
Dr. George Khachatourians
Dr. Zeb Pietrasik
Mr. Derrick Pobereznek
Mr. Paul Rogers
Mr. Ryan Sefton
Ms. Heather Silcox
Ms. Gail Soehn
Dr. Bob Tyler
Dr. Janitha Wanasundara
Ms. Cindy Yu

College of Agriculture

Mr. Dan Aussant
Ms. Colleen Romuld

Department of Agricultural Economics

Ms. Ann Cooney
Dr. Jill Hobbs

Saskatchewan Food Industry Development Centre

Mr. Dan Prefontaine
Ms. S.Y.C. Lui

Western College of Veterinary Medicine

Dr. Murray Woodbury

Saskatchewan Agriculture, Food and Rural Revitalization

Mr. Bob Drysdale
Mr. Murray Feist
Ms. Catherine Folkerson

Dr. Hamid Javed

Dr. Marshall Patterson
Mr. Jason Skotheim